17358/B

N. VII

18/c

Digitized by the Internet Archive
in 2016 with funding from
Wellcome Library

https://archive.org/details/b2877176x_0003

ELEMENTS

OF

Jn Barrett
Edinbro

CHEMISTRY.

By M. I. A. CHAPTAL,

CHEVALIER OF THE ORDER OF THE KING, PROFESSOR OF CHEMISTRY
AT MONTPELLIER, HONORARY INSPECTOR OF THE MINES OF
FRANCE, AND MEMBER OF SEVERAL ACADEMIES OF
SCIENCES, MEDICINE, AGRICULTURE, INSCRIPTIONS AND BELLES LETTRES.

TRANSLATED FROM THE FRENCH.

THE THIRD EDITION.

IN THREE VOLUMES.

VOL. III.

LONDON:
PRINTED FOR G. G. AND J. ROBINSON,
PATERNOSTER-ROW,
BY R. NOBLE, IN THE OLD BAILEY.

1800.

WELLCOME
HISTORICAL
MEDICAL
LIBRARY

CONTENTS

OF THE

THIRD VOLUME.

PART THE FOURTH.

CONCERNING VEGETABLE SUBSTANCES.

Page
INTRODUCTION — — 1

SECTION I.

Concerning the Structure of Vegetables 11
Art. I. Concerning the Bark — — 12
Art. II. Concerning the Ligneous Texture — 15
Art. III. Concerning the Veſſels — 16
Art. IV. Concerning the Glands — 19

SECTION II.

Concerning the Nutritive Principles of Vegetables — — 20
Art. I. Concerning Water, as a Nutritive Principle of Plants — — 22

Art. II. Concerning Earth, and its Influence in Vegetation — — 26
Art. III. Concerning Nitrogenous Gas, as a Nutritive Principle of Plants — — 31
Art. IV. Concerning the Carbonic Acid, as a Nutritive Principle of Vegetables — 31
Art. V. Concerning Light, and its Influence on Vegetation — — 33

SECTION III.

Concerning the Reſults of Nutrition, or the Vegetable Principles — 36

Art. I. Concerning Mucilage — 36
Art. II. Concerning Oils — 41
Division I. Concerning Fixed Oils — 43
Division II. Concerning Volatile Oils — 56
Concerning Camphor — — 64
Art. III. Concerning Reſins — 69
Art. IV. Concerning Balſams — 77
Art. V. Concerning Gum Reſins — 82
Concerning Caoutchouc, or Elaſtic Gum — 87
Concerning Varniſh — — 91
Art. VI. Concerning the Fecula of Vegetables 96
Art. VII. Concerning the Vegetable Gluten 103
Art. VIII. Concerning Sugar — 108
Art. IX. Concerning the Vegetable Acids — 119
Art. X. Concerning Alkalis — — 137
Art. XI. Concerning the Colouring Principles 140
Art. XII. Concerning the Pollen, or Fecundating Powder of the Stamina of Vegetables — 160
Concerning Wax — — 163
Art. XIII. Concerning Honey — 165

Art.

Art. XIV. Concerning the Ligneous Part of Vegetables — — 166
Art. XV. Concerning other Fixed Principles of the Vegetable Kingdom — — 169
Art. XVI. Of the Common Juices extracted by Inciſion or Expreſſion — — 172
Concerning the Juices extracted by Inciſion 175
Concerning Vegetable Juices extracted by Preſſure — — 181

SECTION IV.

Concerning ſuch Principles as eſcape from Vegetables by Tranſpiration — 184

Art. I. Concerning Oxigenous Gas afforded by Vegetables — — 184
Art. II. Concerning the Water afforded by Vegetables — — 188
Art. III. Concerning the Aroma, or Spiritus Rector — — — 189

SECTION V.

Concerning the Alterations to which Vegetables are ſubject after they are deprived of Life — — 194

Chap. I. Concerning the Action of Heat upon Vegetable Subſtances — — 195
Chap. II. Concerning the Action of Water ſingly applied to Vegetables — — 202
Concerning Pit-Coal — — 209
Concerning Volcanos — — 221
Chap. III. Concerning the Decompoſition of Vegetables in the Bowels of the Earth — 231

Chap. IV. Concerning the Action of Air and Heat upon Vegetables — — 233
Chap. V. Concerning the Action of Air and Water, which determine a Commencement of Fermentation that ſeparates the Vegetable Juices from the Ligneous Part — — 236
Chap. VI. Concerning the Action of Air, of Heat, and of Water upon Vegetables — 239
Art. I. Concerning the Spirituous Fermentation and its Products — — 243
Concerning Tartar — — 264
Art. II. Concerning the Acid Fermentation 268
Art. III. Concerning the Putrid Fermentation 273

PART V.

CONCERNING ANIMAL SUBSTANCES.

Introduction — — 279
Chap. I. Concerning Digeſtion — 285
Chap. II. Concerning Milk — 289
Chap. III. Concerning the Blood — 302
Chap. IV. Concerning Fat — 309
Chap. V. Concerning the Bile — 315
Chap. VI. Concerning the Soft and White Parts of Animals — — 322
Chap. VII. Concerning the Muſcular and Fleſhy Parts — — 329
Chap. VIII. Concerning Urine — 334
Concerning the Calculus of the Bladder — 345
Chap. IX. Concerning Phoſphorus — 350

Chap. X. Concerning certain Subſtances obtained from Animals for the Uſe of Medicine and the Arts — — 370
Art. I. Concerning the Products afforded by Quadrupeds — — 371
Art. II. Concerning certain Products afforded by Fiſhes — — 376
Art. III. Concerning certain Products afforded by Birds — — 378
Art. IV. Concerning certain Products afforded by Inſects — — 381
Chap. XI. Concerning ſome other Acids extracted from the Animal Kingdom — 388
Chap. XII. Concerning Putrefaction — 392

ELEMENTS

OF

CHEMISTRY.

PART THE FOURTH.

CONCERNING VEGETABLE SUBSTANCES:

INTRODUCTION.

THE mineral bodies upon which we have hitherto treated, poſſeſs no life, or vital principle, properly ſpeaking; neither do they exhibit any phenomena dependant upon internal organization. The cryſtallization affected by ſubſtances of this kingdom, appears to be exceedingly different from the organization of living beings. It produces no advantage to the individual; and at moſt ſerves only to prove the great harmony of nature, which marks its ſeveral productions with conſtant and invariable forms. But the organization of vegetable and animal beings diſpoſes thoſe bodies in ſuch a manner as is reſpectively the moſt proper to accompliſh the two final purpoſes of nature; namely the ſubſiſtence and reproduction of the individual.*

It cannot be denied that vegetables are endued with a principle of irritability, which develops in them both ſenſation and motion: the motion is ſo evident in certain plants, that it may be produced at pleaſure, as in the ſenſitive plant, the ſtamina of the opuntia, &c. The plants which follow the courſe of the ſun; thoſe which in hot-houſes incline towards the apertures that admit the light; other plants which contract and ſhut up by the puncture of an inſect; thoſe whoſe roots turn out of their direct or original courſe to plunge themſelves into a favourable ſoil, or water—have not theſe a degree of ſenſation of touch which may be compared to the ſenſibility of animals? The difference of the ſecretions in various organs, ſuppoſes a difference in the irritability of each reſpective part.

---

* For the development of theſe principles, ſee La Theſe ſur l'Analyſe Vegetal, ſupported at the ſchools of Montpellier by my ſcholar and friend, M. Riche.

The reproduction of vegetables is effected in the ſame manner as that of animals; and modern botaniſts have ſupported the compariſon between theſe two functions in the moſt happy and concluſive manner.

Vegetables are nouriſhed with air in the ſame manner as inſects. This aliment is even of indiſpenſable neceſſity, for without it the plant at laſt periſhes; though the air which this order of beings requires, is neither of the ſame purity nor of the ſame kind.

The great difference which exiſts between vegetables and animals is, that the latter in general are capable of conveying themſelves from place to place, in ſearch of nouriſhment; whereas vegetables, being fixed in the ſame place, are obliged to take up in their own vicinity all ſuch matters as are capable of nouriſhing them: and nature has provided them with leaves, to extract from the atmoſphere the air and water of which they have need; while their roots extend to a diſtance in the earth, to take firm hold, as well as to receive other nutritive principles.

If we attend more minutely to the character of animals, we ſhall perceive that nature deſcends by imperceptible degrees from animals of the moſt complicated organization to vegetables; and we ſhall find it difficult to determine where one kingdom terminates, and the other begins. Chemical analyſis is capable of marking the limits between theſe kingdoms in an imperfect manner. For a long time it was pretended that animal ſubſtances poſſeſſed the excluſive property of affording ammoniac, or the volatile alkali; but it is at preſent well known that certain plants likewiſe afford it. We may in ſtrictneſs conſider a vegetable as a being that participates in the laws of animal life, but in a leſs degree than the animal itſelf.

The difference which has been eſtabliſhed between the vegetable and the mineral kingdoms, is much more ſtriking. We may conſider this laſt as a maſs deprived of organization, and almoſt in an elementary ſtate; receiving no modifications or changes but by the impreſſion of external objects; capable of entering into combinations; of changing its nature; and of re-appearing, or being reproduced with its original properties, at the pleaſure of the chemiſt. The other kingdom, on the contrary, being endued with a particular life, which inceſſantly modifies the impreſſion of external objects, decompoſing them, and changing their nature, exhibits to us a ſeries of functions regular throughout, and almoſt all of them inexplicable; and when the chemiſt has ſucceeded in depriving theſe bodies of their organization, and ſeparating their principles, he finds it beyond his power to reproduce it by any re-union of the ſame principles.

In the mineral kingdom, we are juſtified in referring all the phenomena to the action of external bodies; and forces purely phyſical, or the ſimple laws of affinity, afford deductions ſufficient to account for all its metamorphoſes. In the vegetable kingdom, on the contrary, we are compelled to acknowledge an internal force which performs every thing, governs all the proceſſes, and ſubjects to its deſigns thoſe agents which have an abſolute empire over the mineral kingdom.

The mineral poſſeſſes no evident life, no period which may be conſidered as the term of its perfection; becauſe its various ſtates are always relative to the purpoſes to which we intend to apply it. It does not appear either to grow or to be reproduced: at moſt it changes its form, but never by any internal determination; this is always the mere phyſical effect of the action of external objects. In thoſe caſes wherein the mineral exhibits marks of increaſe or vegetation, it is by the ſucceſſive application of ſimilar materials worn and tranſported by the waters. In theſe apparent vegetations we perceive neither elaboration nor deſign: the law of affinities ever preſides in theſe arrangements; and this law is the law of bodies void of life.

It is not therefore ſurpriſing that the chemical analyſis ſhould have made leſs progreſs in the vegetable than in the mineral kingdom, for it becomes more difficult in proportion as the functions are complicated; and in the vegetable kingdom the conſtituent parts are more numerous, at the ſame time that they are leſs eaſily diſtinguiſhed by characteriſtic properties; and the methods of analyſis hitherto employed are all imperfect; not to mention that the proceedings of chemiſts have likewiſe been conducted upon an erroneous principle.

All plants have hitherto been analyſed either by fire or by menſtruums. The firſt of theſe methods is very uncertain; for the action of fire decompoſes combined bodies, alters their principles, forms new bodies by the combination of theſe ſeparate elements, and extracts nearly the ſame principles from very different ſubſtances. Long experience has ſhewn the imperfection

perfection of this method. Meſſrs. Dodart, Bourdelin, Tournefort, and Boulduc, have diſtilled more than fourteen hundred plants; and it was from the reſults of ſo extenſive a work that Homberg deduced ſufficient reaſons to conclude that this method is erroneous. As a proof of his aſſertion, he quotes the analyſis of cabbage and hemloc, which afforded the ſame principles by diſtillation.

The method by menſtruums is ſomewhat more accurate, becauſe it does not change the nature of the products: it has been even of greater advantage to medicine, by affording methods of ſeparating the medicinal principle from certain vegetables. It has alſo afforded its aſſiſtance to extract other principles in all their purity, which are uſeful in the arts, or for the purpoſes of life; and it has given us more inſtruction concerning the nature of vegetable principles. But we cannot confine ourſelves to this ſingle method in the analyſis of plants; and a conſiderable ſhare of genius is required in the chemiſt, to vary his proceſs according to the nature of the vegetable, and the character of the principle he is deſirous of extracting.

A reproach of conſiderable weight may be urged againſt moſt of the chemiſts who have written upon the vegetable analyſis: it is, that they have followed no order in their proceedings, nor attended to any regular diſtribution of the facts. They have confined themſelves to indicate proceſſes for extracting ſuch or ſuch ſubſtances, without connecting the whole with any ſyſtem founded either on the methods of operating, on the nature of the products, or on the proceedings followed by nature in its own operations. I confeſs that, if a diſquiſition on the vegetable analyſis were to be confined to the proceſſes neceſſary to be known in extracting the ſeveral ſubſtances, the ſyſtem of order and of method which I propoſe would be uſeleſs; but if it be an object to know the operation of nature, and to ſurvey the vegetable kingdom like a philoſopher, a naturaliſt, and a chemiſt, it is neceſſary to inſpect the operations of nature herſelf among vegetables, and to follow as much as poſſible a plan which ſhall render us acquainted with the plant under all theſe points of view: that which I have adopted appears to me to anſwer that purpoſe.

We ſhall begin by exhibiting a curſory account of the vegetable ſtructure, in order that we may become better acquainted with the connection between its organization and the principles which we ſhall extract.

In the ſecond place we ſhall attend to the development and increaſe of the vegetable. With this intention we ſhall ſhew the various principles which ſerve for its nouriſhment; and we ſhall follow their alterations in the vegetable œconomy as much as we are enabled to do. We ſhall therefore of conſequence examine the influence of the air, the ſoil, the light, &c.

In the third place we ſhall examine the reſults of the work of organization upon elementary ſubſtances; and for that purpoſe we ſhall teach the method of diſtinguiſhing the ſeveral conſtituent principles of vegetables; taking care to proceed in this examination according to that method which nature herſelf points out.

Thus we ſhall begin with the analyſis of ſuch products as we can extract without deſtroying the organization of the plant, and which are exhibited in a naked ſtate by that organization: ſuch as the mucilage, the gums, the oils, the reſins, the gum reſins, &c. We ſhall in the next place analyſe ſuch principles as cannot be collected but by deſtroying the organization of the plant; ſuch as the fecula, the glutinous part, the ſugar, the acids, the alkalis, the neutral ſalts, the colouring principles, the extractive matter, iron, gold, manganeſe, ſulphur, &c.

We ſhall likewiſe attend to the prolific humours of vegetables; that is to ſay, the examination of ſuch ſubſtances as, though neceſſary to life, are urged outwards to anſwer certain functions: the pollen and honey are of this kind.

We ſhall afterwards examine the humours which evaporate and eſcape by tranſpiration; ſuch as oxigenous gas, the aqueous principle, the aroma, or odorant principle, &c.

And in the laſt place we ſhall ſhew the alterations to which vegetables are ſubjected after death. In order to proceed with regularity in a queſtion of ſuch great importance, we ſhall ſucceſſively examine the action of heat, of the air, and of water, upon the vegetable, whether they act ſeparately or together. This proceeding will render us acquainted with all the phenomena exhibited by vegetables in their decompoſition.

SECTION I.

Concerning the Structure of Vegetables.

EVERY vegetable exhibits in its ſtructure. 1. A fibrous and hard mechaniſm, which ſupports all the other organs, determines the direction, and gives the proper ſolidity to the ſeveral plants and their parts. 2. A cellular tiſſue, which accompanies all the veſſels, envelops all the fibres, contorts itſelf in a thouſand ways, and every where forms coverings and a net-work which connect all the parts, and eſtabliſh an admirable communication between them. We ſhall deſcribe the ſeveral parts of plants in a very conciſe manner, and ſhall confine ourſelves to the explanation and deſcription of ſuch organs as muſt neceſſarily be known with accuracy, before we can proceed to the analyſis of plants.

ARTICLE I.

Concerning the Bark.

The bark is the external covering of plants: its prolongations or extenſions cover all the parts which compoſe the vegetable. We may diſtinguiſh three particular tunics, which may be ſeparately detached and obſerved; the epidermis, the cellular tiſſue, and the cortical coatings.

1. The epidermis is a thin membrane, formed of fibres that croſs each other in every direction: its texture is ſometimes ſo thin, that the direction of its fibres may be ſeen by holding it againſt the light. This membrane is eaſily detached from the bark when the plant is in a vigorous ſtate; and when it is dried the ſeparation may be effected by ſteeping it in water. When the epidermis of a plant is deſtroyed, it grows again; but is then more ſtrongly adherent to the reſt of the bark, ſo as to form a kind of cicatrice.

This epidermis appears to be intended by nature to modify the impreſſions of external objects upon the vegetable; to furniſh a great number of pores, which tranſmit or throw off the excretory products of vegetation; to protect the laſt or extreme ramification of the aërial or aqueous veſſels, which extract out of the air ſuch fluids as are neceſſary for the increaſe of the vegetable; and to cover the cellular organ, which contains the principal veſſels, and thoſe glands in which the ſeveral fluids are digeſted and elaborated.

2. The cellular coating forms the ſecond part of the bark. Its texture conſiſts of veſicles and utricles, ſo very numerous, and ſo cloſe together, as to form a continued coating. It is among theſe glands that the work of digeſtion appears to be performed; and the product of this elaboration is afterwards conveyed through the whole vegetable, by veſſels propagated through all its parts and communications; even with the medullary ſubſtance or pith, by conduits that paſs through the body of the tree, croſſing the ligneous ſtrata. In this net-work it is that the colouring matter of vegetables is developed: the light which penetrates the epidermis concurs in enlivening the colour: here likewiſe it is that oils and reſins are formed, by the decompoſition of water and the carbonic acid; and laſtly it is from this reticular ſubſtance that thoſe various products of the organization are thrown off or excluded,

which may be conſidered as the fæces of the vegetable digeſtion.

3. The coatings which lie between the external covering and the wood or body of the vegetable, and may be called the cortical coatings, are formed of laminæ which themſelves conſiſt of the re-union of the common, proper, and air-veſſels of the plant. The veſſels are not extended lengthwiſe along the ſtem, but are curved in various directions, and leave openings or meſhes between them, which are filled by the cellular matter itſelf. Nothing more is neceſſary to ſhew the organization, than to macerate theſe coatings in water, which deſtroys the cellular ſubſtances, and leaves the net-work uncovered.* The cortical coverings are eaſily detached from each other; and it is from their groſs reſemblance to the leaves of a book, that they have been called *liber*. In proportion as theſe coatings approach the ligneous body, they become hard; and at length form the external ſofter part of the wood, which workmen call the ſap.

The bark is the moſt eſſential part of the vegetable, by means of which the principal functions of life, ſuch as nutrition, digeſtion, the ſecretions, &c. are performed. All plants, and particularly thoſe which are hollow within, and whoſe products are totally changed by covering them with a different bark, prove evidently that the digeſtive force eminently reſides in this part. The ligneous part is ſo far from being eſſential, that many plants are without it, ſuch as the gramineous and the arundinaceous, and all plants that are hollow within. Graſſes, properly ſpeaking, have only the cortical part. We often ſee plants internally rotten, but kept in vigour by the good ſtate of their bark.

---

* This is moſt particularly ſeen in the *arbre à dentelle*, when the plant has been macerated in water.

ARTICLE II.

Concerning the Ligneous Texture.

Beneath the bark there is a ſolid ſubſtance, which forms the trunk of trees, and appears to be uſually compoſed of concentric layers. The interior coatings or rings are harder than the exterior; they are older, and of a more firm and cloſe grain. The hardeſt of theſe form the wood, properly ſo called, while the ſofter external rings conſtitute the ſap. We may conſider wood as being formed of fibres, more or leſs longitudinal, connected together by a cellular tiſſue, interſperſed with veſicles communicating with each other; which diminiſh gradually towards the centre, where they form the pith. The pith is found only in young branches or plants, and diſappears in plants of a certain age.

The veſicular tiſſue bears a great analogy with the glandular and lymphatic veſſels of the human body: in both, the conformation and uſes are the ſame. In the early age of plants and animals, the organs have a conſiderable expanſion, becauſe the increaſe of the individual is very rapid at that period. But, as age advances, the veſſels become obliterated in both kingdoms; and it is obſerved that, in the white woods and fungi which abound with the veſicular ſubſtance, the growth is alſo very rapid.

ARTICLE III.

Concerning the Veſſels.

The various humours of vegetables are contained in certain appropriated veſſels, in which they enjoy a degree of motion that has been compared to the circulation in animals. It differs from it, however; becauſe theſe humours are not continually kept in equilibrio in the veſſels by an inherent force, but receive in a more evident manner the impreſſion of external agents. Light and heat are the two great cauſes which determine and modify the motion of the fluids and vegetables. Theſe agents cauſe the ſap to riſe into the various parts, where it is elaborated in a manner correſpondent to the functions of each; but it is not obſerved that it returns: ſo that the acceſſion or flux of the humours in vegetables is proved, but the reflux does not appear to be perceptible.

Three kinds of veſſels may be diſtinguiſhed in vegetables: the common, or ſap veſſels; the proper veſſels; and the air veſſels, or tracheæ.

1. The ſap veſſels convey the ſap, or general humour, from which all the others are derived. This liquor may be compared to the blood in animals. Theſe veſſels are reſervoirs from which the ſeveral organs extract the different juices, and elaborate them in a proper manner.

The ſap veſſels chiefly occupy the middle of plants and trees. They riſe perpendicularly, though with deflexions ſideways, ſo as to communicate with all the parts of the vegetable: They convey the ſap into the utricles; whence it is taken by the proper veſſels, in order that it may be duly elaborated.

2. Each organ is likewiſe provided with

peculiar veſſels, to ſeparate the various juices, and to preſerve them, without ſuffering them to mix with the general maſs of humours. Thus it is that we find in the ſame vegetable, and frequently in the ſame organ, juices of different natures, and greatly differing in colour and conſiſtence.

The veſſels, whether common or proper, are retained in their ſeveral directions by the ligneous fibres; they are every where ſurrounded by the cellular tiſſue; they open, and pour their fluids into the glands, into the cellular tiſſue, and into the utricles, to anſwer the various functions.

The utricles are ſmall veſſels or repoſitories which contain the pith, and frequently the colouring matter. They form a kind of repoſitory in which the nutritive juice of the plant is preſerved, and whence it is taken on occaſion; in the ſame manner as the collection of marrow is formed in the internal part of the bones, whence it is afterwards extracted when the animal is not ſufficiently ſupplied with nutriment.

3. The tracheæ, or air-veſſels, appear to be the organs of reſpiration, or rather thoſe which receive the air, and facilitate its abſorption and decompoſition. They are called tracheæ on account of the reſemblance which is thought to exiſt between them and the reſpiratory or-

gans of inſects. In order to obſerve them, a branch of a tree is taken ſufficiently young to break off ſhort: after having cleared away the bark without touching the wood, the bough is broken by drawing the two extremities in oppoſite directions; the tracheæ are then ſeen in the form of ſmall corkſcrews, or veſſels turned in a ſpiral direction. It is generally ſuppoſed that the large pores which are perceived in the tranſverſe ſection of a plant, viewed in a microſcope are merely air-veſſels. It often happens that the ſap is extravaſated in the cavity of the tracheæ; and they appear incapable of ſerving any other purpoſes than that of conveying the air, at leaſt for ſome time, unleſs a change take place in the life of the plant.

ARTICLE IV.

Concerning the Glands.

Small protuberances are obſerved upon various parts of vegetables. Theſe are glandular bodies, whoſe form is prodigiouſly varied. It is more particularly upon this variation of form that Mr. Guettard has grounded his ſeven ſpecies. They are almoſt always filled with a humour, whoſe colour and nature are ſingularly varied.

SECTION II.

Concerning the Nutritive Principles of Vegetables.

IF plants were to perform no other act than that of pumping the nutritive principles they contain out of the earth; if they did not poſſeſs the faculty of digeſting, aſſimilating them, and forming different products, according to their nature, and the diverſity of their organs; it would follow, as a conſequence, that we ought to find in the earth all thoſe principles which analyſis exhibits to us in vegetables: a concluſion which is contradicted by the facts; for we ſhall hereafter prove, that the production of vegetable earth is an effect of the organization of plants, and that it owes its formation to them inſtead of communicating principles ready formed to thoſe individuals. If it were true that plants did nothing but extract their component parts out of the earth, thoſe plants which grow on the ſame ſoil would poſſeſs the ſame principles, or at leaſt the analogy between them would be very great; whereas we find plants of very different virtues and flavours grow and flouriſh beſide each other. In addition to this we may obſerve, that ſuch plants as are raiſed in pure water—the fat plants, which grow without being fixed to the earth, provided they are placed in a moiſt atmoſphere—the claſs of paraſitical plants, which do not partake of the properties of thoſe which ſerve to ſupport them—prove that a vegetable does not derive its juices from the earth, on account of its being earth; but that it poſſeſſes an internal alterative and aſſimilating power, which appropriates to each individual the aliment which is ſuitable to it, at the ſame time that it diſpoſes and combines that aliment to form certain peculiar principles. This digeſtive virtue will appear to be aſtoniſhingly perfect, when it is conſidered that the nutriment common to all vegetables is very little varied, ſince we know only of the water and air; and conſequently that it poſſeſſes the power of forming very different products with theſe two ſimple principles. But from this circumſtance, that the nutritive principles of plants are very ſimple, it muſt be preſumed that, in the various reſults of digeſtion, or (which is the ſame thing) in the vegetable ſolids and fluids, there muſt be the greateſt analogy; and that the differences are deducible from the proportion of the principles, and their more or leſs perfect combination, rather than from their variety. With this intention we ſhall carefully obſerve the tranſition from one principle to another; and ſhall explain the art of reducing them all to certain elementary or primitive ſubſtances, ſuch as the fibrous matter, mucilage, &c.

ARTICLE I.

Concerning Water, as a Nutritive Principle of Plants.

Every one knows that a plant cannot vegetate without the aſſiſtance of water: but it is not ſo generally known that this is the only aliment which the root draws from the earth; and that a plant can live, and propagate itſelf, without any other aſſiſtance than the contact of water and air. It appears to me, nevertheleſs, that the following experiments remove every doubt on the ſubject;—Van Helmont planted a willow, weighing fifty pounds, in a certain quantity of earth covered with ſheet lead: he watered it for five years with diſtilled water; and at the end of that time the tree weighed one hundred and ſixty-nine pounds three ounces, and the earth in which it had vegetated was found to have ſuffered a loſs of no more than three ounces. Boyle repeated the ſame experiment upon a plant, which at the end of two years weighed fourteen pounds more, without the earth in which it had vegetated having loſt any perceptible portion of its weight.

Meſſrs. Duhamel and Bonnett ſupported plants with moſs, and fed them with mere water; they obſerved that the vegetation was of the moſt vigorous kind; and the naturaliſt of Geneva obſerves, that the flowers were more odoriferous, and the fruit of a higher flavour. Care was taken to change the ſupports before they could ſuffer any alteration. Mr. Tillet has likewiſe raiſed plants, more eſpecially of the gramineous kind, in a ſimilar manner; with this difference only, that his ſupports were pounded glaſs, or quartz in powder. Hales has obſerved that a plant which weighed three pounds gained three ounces after a heavy dew. Do we not every day obſerve hyacinths and other bulbous plants, as well as gramineous plants, raiſed in ſaucers or bottles containing mere water?

All plants do not demand the ſame quantity of water; and nature has varied the organs of the ſeveral individuals conformably to the neceſſity of their being ſupplied with this food. Plants which tranſpire little, ſuch as the moſſes and the lichens, have no need of a conſiderable quantity of this fluid; and accordingly they are fixed upon dry rocks, and have ſcarcely any roots: but plants which require a larger quantity have roots which extend to a great diſtance, and abſorb humidity throughout their whole ſurface.

The leaves of plants have likewiſe the property of abſorbing water, and of extracting from the atmoſphere the ſame principle which the root draws from the earth. But plants which live in the water, and as it were ſwim in the element which ſerves them for food, have no need of roots; they receive the fluid at all their pores: and we accordingly find that the fucus, the ulva, &c. have no roots whatever. The purer the water, the more ſalutary it is to plants. Mr. Duhamel has drawn this conſequence from a ſeries of well-made experiments, by which he has proved that water impregnated with ſalts is fatal to vegetation. Hales cauſed them to abſorb various fluids, by making inciſions in their roots, and plunging them in ſpirits of wine, mercury, and various ſaline ſolutions; but he was convinced that theſe were all poiſons to the vegetables.

Beſides, if theſe ſalts were favourable to the plants, they would be again found in the individual which had been watered with a ſolution of them; whereas Meſſrs. Thouvenel and Cornette have proved that theſe ſalts do not paſs into the vegetable. We muſt nevertheleſs except the marine plants, becauſe the ſea ſalt of which they have need is decompoſed in them, and produces a principle which appears neceſſary to their exiſtence, ſince they languiſh without it.

Though it is proved that pure water is more proper for vegetation than water charged with ſalts, it muſt not on that account be concluded that water cannot be diſpoſed in a more favourable manner to the development of vegetables, by charging it with the remains of vegetable and animal decompoſition. If, for example, the water be loaded with principles diſengaged by fermentation or putrefaction, the plant then receives juices already aſſimilated to its nature; and theſe prepared aliments muſt haſten its growth. Independent of thoſe juices already formed, the nitrogene gas, which conſtitutes one of the nutritive principles of plants, and is abundantly afforded by the alteration of vegetables and animals, muſt facilitate their development. A plant ſupported by the remains of vegetables and animals, is in the ſame ſituation as an animal fed on milk only; its organs have leſs difficulty in elaborating this drink, than that which has not yet been animalized.

The dung which is mixed with earths, and decompoſed, not only affords the alimentary principles we have ſpoken of, but likewiſe favours the growth of the plant by that conſtant and ſteady heat which its ulterior decompoſition produces. Thus it is that Fabroni affirms his having obſerved the development of leaves and flowers in that part of a tree only which was in the vicinity of a heap of dung.

ARTICLE II.

Concerning Earth, and its Influence in Vegetation.

Although it be well proved that pure water is ſufficient for the ſupport of plants, we muſt not conſider the earth as of no uſe. Its utility reſembles that of the placenta, which of itſelf affords no ſupport to the life of the infant, but which prepares and diſpoſes the blood of the mother to become a ſuitable nouriſhment: or it reſembles, and has a ſimilar utility with, the various reſervoirs which nature has placed in the body of man, to preſerve the ſeveral humours, and emit them upon occaſion. The earth imbibes and retains water: it is the reſervoir deſtined by nature to preſerve the elementary juice which the plant continually requires; and to furniſh that fluid in proportion to its wants, without expoſing it to the equally fatal alternatives of being either inundated or dried up.

We even ſee that, in the young plant or embryo, nature has not choſen to entruſt the labour of digeſtion to the ſtill feeble germen. The ſeed is formed of a parenchyma, which imbibes water, elaborates it, and does not tranſmit it to the germen until it is reduced into juice or humour. By inſenſible gradations this ſeed is deſtroyed; and the plant, become ſufficiently ſtrong, performs the work of digeſtion without aſſiſtance. In the ſame manner it is that we perceive the fœtus ſupported in the womb of its mother by the humours of the mother herſelf; but, when it has ſeen the light, it receives for nouriſhment a fluid leſs animalized, its organs are gradually ſtrengthened, and at length become capable of digeſting a ſtronger and leſs aſſimilated nouriſhment.

But on this very account, that the earth is deſtined to tranſmit to the plant that water which is to ſupport it, the nature of the ſoil cannot be a matter of indifference, but muſt be varied accordingly as the plant requires a more or leſs conſiderable quantity of water, accordingly as it demands more or leſs in a given time, and accordingly as its roots extend to a greater or leſs diſtance. It may therefore be immediately perceived that every kind of earth is not ſuitable for every plant, and conſequently that a ſlip cannot be grafted indifferently upon every ſpecies.

A proper ſoil is that—1. Which affords a ſufficiently firm ſupport to prevent the plant from being ſhaken. 2. Which permits the roots to extend themſelves to a diſtance with eaſe. 3. Which becomes impregnated with humidity, and retains the water ſufficiently that the plant may not be without it when wanted. To anſwer theſe ſeveral conditions, it is neceſſary to make a proper mixture of the primitive earths, for none of them in particular poſſeſſes them. Siliceous and calcareous earths may be conſidered as hot and drying, the argillaceous as moiſt and cold, and the magneſian as poſſeſſing intermediate properties. Each in particular has its faults, which render it unfit for culture: clay abſorbs water, but does not communicate it;

calcareous earth receives and gives it too quickly: but the properties of theſe earths are ſo happily oppoſed, that they correct each other by mixture. Accordingly we find that, by adding lime to an argillaceous earth, this laſt is divided; and the drying property of the lime is mitigated, at the ſame time that the ſtiffneſs of the clay is diminiſhed. On theſe accounts it is that a ſingle earth cannot conſtitute manure; and that the character of the earth intended to be meliorated ought to be ſtudied, before the choice of any addition is decided on. Mr. Tillet has proved that the beſt proportions of a fertile earth for corn, are three-eighths of clay, two-eighths of ſand, and three-eighths of the fragments of hard ſtone.

The advantage of labour conſiſts in dividing the earth, aërating it, deſtroying uſeleſs or noxious plants, and converting them into manure, by facilitating their decompoſition.

Before we had acquired a knowledge of the conſtituent principles of water, it was impoſſible to explain, or even to conceive, the growth of plants by this ſingle aliment. In fact, if the water were an element, or indecompoſable principle, it would afford nothing but water in entering into the nutrition of the plant, and the vegetable would of courſe exhibit that fluid only: but when we conſider water as formed by the combination of the oxigenous and hydrogenous gaſes, it is eaſily underſtood that this compound is reduced to its principles; and that the hydrogenous gas becomes a principle of the vegetable, while the oxigene is thrown off by the vital forces. Accordingly we ſee the vegetable almoſt entirely formed of hydrogene. Oils, reſins, and mucilage, conſiſt of ſcarcely any thing but this ſubſtance; and we perceive the oxigenous gas eſcape by the pores, where the action of light cauſes its diſengagement. This decompoſition of water is proved not only in vegetable, but likewiſe in animal bodies. Rondelet (*Lib. de Piſc.* lib. i. cap. 12.) cites a great number of examples of marine animals which cannot ſubſiſt but by means of water, by the very conſtitution of their organs. He affirms that he kept, during three years, a fiſh in a veſſel conſtantly maintained full of very pure water: it grew to ſuch a ſize, that at the end of that time the veſſel could no longer contain it. He relates this as a very common fact. We likewiſe obſerve the red fiſhes, which are kept in glaſs veſſels, are nouriſhed, and grow, without any other aſſiſtance than that of the water properly renewed.

ARTICLE III.

Concerning Nitrogenous Gas, as a Nutritive Principle of Plants.

Vegetables cannot live without air; but the air they require is not the ſame as is appropriated to man. Drs. Prieſtley, Ingenhouſz, and Mr. Senebier, have proved that it is the nitrogenous gas which more particularly ſerves them for aliment. Hence it ariſes that vegetation is more vigorous when a greater quantity of thoſe bodies which afford this gas by their decompoſition are preſented to the plant; theſe are, animals or vegetables in a ſtate of putrefaction. As the baſis of nitrogenous gas is unknown to us, it is difficult to conceive what may be its effect upon the vegetable œconomy, and we cannot follow it after its introduction into the vegetable. We do not find it again until the decompoſition of the vegetable itſelf, when it reappears in the gaſeous form.

ARTICLE IV.

Concerning the Carbonic Acid, as a Nutritive Principle of Vegetables.

The carbonic acid which is diſperſed in the atmoſphere, or in waters, may likewiſe be conſidered as an aliment of plants; for theſe bodies poſſeſs the power of abſorbing and decompoſing it when its quantity is ſmall. The baſe of this acid even ſeems to contribute to the formation of vegetable fibres: for I have obſerved that this acid predominates in the fungus, and other ſubterraneous plants. But by cauſing theſe vegetables, together with the body upon which they are fixed, to paſs by imperceptible gradations from an almoſt abſolute darkneſs into the light, the acid very nearly diſappeared; the vegetable fibres being proportionally increaſed, at the ſame time that the reſin and colouring principles were developed by the oxigene of the ſame acid. Senebier has obſerved, that the plants which he watered with water impregnated with the carbonic acid, tranſpired a much greater quantity of oxigenous gas; which proves a decompoſition of the carbonic acid.

Vegetation may therefore be ſucceſsfully employed to correct air too highly charged with carbonic acid, or in which the nitrogenous gas exiſts in too great a proportion.

ARTICLE V.

Concerning Light, and its Influence on Vegetation.

Light is abſolutely neceſſary to plants. Without the aſſiſtance of this principle they become pale, languiſh, and die. But it has not been proved that it enters as an aliment into their compoſition: at moſt it may be conſidered as a ſtimulus or agent which decompoſes the various nutritive principles, and ſeparates the oxigenous gas ariſing from the decompoſition of water, or the carbonic acid, while their baſes become fixed in the plant itſelf.

The moſt immediate effect of the fixation of the various ſubſtances, and the concretion of the liquids which ſerve as the food of plants, is a ſenſible production of heat, which cauſes plants to participate very little in the temperature of the atmoſphere. Dr. Hunter obſerved, by keeping a thermometer plunged in a hole made in a ſound tree, that it conſtantly indicated a temperature ſeveral degrees above that of the atmoſphere, when it was below the fifty-ſixth diviſion of Fahrenheit; whereas the vegetable heat, in hotter weather, was always ſeveral degrees

grees below that of the atmoſphere. The ſame philoſopher has likewiſe obſerved, that the ſap which, out of the tree, would freeze at 32°, did not freeze in the tree unleſs the cold were augmented 15° more.

The vegetable heat may increaſe or diminiſh by ſeveral cauſes, of the nature of diſeaſe; and it may even become perceptible to the touch in very cold weather, according to Mr. Buffon.

The heat produced in healthy vegetables, by the before-mentioned cauſes, continually tempers the cold of the atmoſphere; the evaporation which takes place through the whole body of the tree, continually moderates the ſcorching heat of the ſun; and theſe productive cauſes of cold or heat are more effectual, in proportion as the heat or cold of external bodies acts with greater energy.

The property which plants poſſeſs of converting nitrogenous gas and carbonic acid into nouriſhment, eſtabliſhes an aſtoniſhing degree of analogy between them and certain inſects. It appears, from the obſervation of Frederic Garman (Ephem. des Curioſ. Nat. Année 1670), that the air may become a real food for the claſs of ſpiders. The larvæ of the ant, as well as of ſeveral inſects of prey which live in the ſand, increaſe in bulk, and undergo their metamorphoſes without any other nouriſhment than that of the air. It has been obſerved that a great number of inſects, particularly in the ſtate of larvæ, are capable of living in the nitrogenous gas, mixed with carbonic acid, and tranſpiring vital air. The abbé *Fontana* has obſerved that ſeveral inſects poſſeſs this property; and *Ingenhouſz*, who is of opinion that the green matter which is formed in water, and tranſpires oxigenous gas by the light of the ſun, is a cluſter of animalculæ, has added to theſe phænomena. Inſects have moreover the organ of reſpiration diſtributed over the whole ſurface of their bodies. Here therefore we obſerve ſeveral very aſtoniſhing points of analogy between inſects and vegetables; and the chemical analyſis adds ſtill more to the reſemblances, ſince inſects and vegetables afford the ſame principles; namely, volatile oils, reſins, diſengaged acids, &c.

SECTION III.

Concerning the Reſults of Nutrition, or the Vegetable Principles.

THE various ſubſtances which afford food to plants, are changed by the organization of the vegetable; from which there reſults a fluid generally diſtributed, and known by the name of Sap. This juice, when conveyed into the ſeveral parts of the plant, receives an infinity of modifications, and forms the ſeveral humours which are ſeparated and afforded by the organs. It is to theſe principles chiefly that we are at preſent about to direct our attention; and we ſhall endeavour in our examination to follow the moſt natural order, by ſubjecting them to analyſis in the ſame order as that in which nature preſents them to us.

ARTICLE I.

Concerning Mucilage.

Mucilage appears to conſtitute the firſt alteration of the elementary juices in vegetables.

Moſt ſeeds are almoſt totally reſolvable into mucilage, and young plants ſeem to be entirely formed of it. This ſubſtance has the greateſt analogy with the mucous fluid of animals. Like that fluid, it is moſt abundant in the earlier periods of life, and all the other principles appear to be derived from it; and in vegetables, as well as animals, its quantity becomes leſs in proportion as the increaſe of magnitude, or growth of the individual, becomes leſs, or ceaſes. Mucilage is not only the nutritive juice of plants and animals; but, when extracted from either, it becomes the moſt nouriſhing and wholeſome food we are acquainted with.

Mucilage forms the baſis of the proper juices, or the ſap, of plants. It is ſometimes found almoſt entirely alone, as in mallows, the ſeeds of the wild quince, linſeed, the ſeeds of thlaſpi, &c. Sometimes it is combined with ſubſtances inſoluble in water, which it keeps ſuſpended in the form of an emulſion; as in the euphorbium, celandine, the convolvulus, and others. In other inſtances it is united with an oil, and forms the fat oils. Frequently it is united with ſugar, as in the gramineous ſeeds, the ſugar-cane, maize, carrot, &c. It is likewiſe found confounded with the eſſential ſalts, with exceſs of acid, as in barberries, tamarinds, ſorrel, &c.

Mucilage ſometimes conſtitutes the permanent ſtate of the plant; as in the tremella, the conferva, ſome lichens, and moſt of the champignons. This exiſtence in the form of mucilage is likewiſe ſeen in certain animals; ſuch as the meduſa or ſea-nettle, the holothurion, &c.

The characters of mucilage are—1. Inſipidity. 2. Solubility in water. 3. Inſolubility in alcohol. 4. Coagulation by the action of weak acids. 5. The emiſſion of a conſiderable quantity of carbonic acid, when expoſed to the action of fire; at the ſame time that it becomes converted into coal, without exhibiting any flame. Mucilage is likewiſe capable of paſſing to the acid fermentation when diluted with water.

The formation of mucilage appears to be almoſt independent of light. Thoſe plants which grow in ſubterraneous places abound with it. But light is required to enable mucilage to paſs to other ſtates; for, without the aſſiſtance of this principle, the ſame plants would obtain ſcarcely any conſiſtence.

That which is called gum, or gummy juices, in commerce, is nothing but dried mucilage. Theſe gums are three in number. They either flow naturally from the trunk of the tree which affords them, or they are obtained by inciſion of the bark.

1. Gum of the country, *Gummi noſtras.*—This gum flows naturally from certain trees in our climate, ſuch as the plum, the peach, the cherry-tree, &c. It firſt appears in the form of a thick fluid, which congeals by expoſure to the air, and loſes the adheſive and gluey conſiſtence which characterizes it in the liquid ſtate. Its colour is white, but more commonly yellow or reddiſh. When pure, it may be advantageouſly ſubſtituted for gum arabic, which is much dearer.

2. Gum arabic.—The gum arabic flows naturally from the acacia in Egypt and Arabia. It is even affirmed that it is not obtained from this tree only, but that the gum met with in commerce is the produce of ſeveral trees. The appearance of this gum is in round pieces, white and tranſparent, wrinkled without, and hollow within; it is likewiſe found in round pieces variouſly contorted. This gum is eaſily ſoluble in water, and forms a tranſparent jelly called mucilage. It is much uſed in the arts and in medicine. It is mild, void of ſmell or taſte, very well adapted to ſerve as the baſis of paſtils, and other preparations uſed as mitigating or ſoftening remedies.

3. Gum adragant.—The gum adragant is nearly of the ſame nature as gum arabic. It

flows from the adragant of Crete, a ſmall ſhrub not exceeding three feet in height. It comes to us in ſmall white tears, contorted, and reſembling little worms. It forms with water a thicker jelly than gum arabic, and may be uſed for the ſame purpoſes.

If the roots of marſhmallows or of the conſolida, linſeed, the kernels of the wild quince, (coing), &c. be macerated in water for a time, they afford a mucilage ſimilar to that of gum arabic.

All theſe gums afford, by diſtillation, water, an acid, a ſmall quantity of oil, a ſmall quantity of ammoniac or volatile alkali, and much coal. This ſketch of analyſis proves that mucilage is compoſed only of water, oil, acid, carbone, and earth; and ſhews that the various principles of the alimentary juices, ſuch as water, the carbonic acid, and nitrogene gas, are ſcarcely changed in this ſubſtance.

Gums are uſed in the arts and in medicine. In the arts they are applied to give a greater degree of conſiſtence to certain colours, and to fix them more permanently upon paper; they are alſo uſed as a preparation to give a firmer body to hats, ribbons, taffetas, &c. Stuffs dipped in gum water acquire a luſtre and brightneſs; but water, and the handling of theſe goods, ſoon deſtroy the illuſion; and theſe proceſſes are claſſed among thoſe which nearly approach to impoſition and deceit. Gum is likewiſe the baſis of moſt kinds of blacking uſed for ſhoes, boots, and the like.

The gums are ordered in medicine as emollients. They compoſe the baſis of many remedies of this kind. The mucilage of linſeed, or of the kernels of wild quinces, is of value in allaying inflammations.

ARTICLE II.

Concerning Oils.

By common conſent the name of Oil is given to fat unctuous ſubſtances, more or leſs fluid, inſoluble in water, and combuſtible.

Theſe products appear to belong excluſively to animals and vegetables. The mineral kingdom exhibits only a few ſubſtances of this nature, which poſſeſs ſcarcely any of the above properties, ſuch as the unctuous property.

Oils are diſtinguiſhed, relative to their fixity, into fat oils, and eſſential oils. We ſhall deſcribe them in this article under the names of Fixed Oils and Volatile Oils. The difference between theſe two kinds of oils does not merely conſiſt in their various degrees of volatility, but alſo in their habitudes with the ſeveral re-agents. The fixed oils are inſoluble in alcohol, but the volatile oils are eaſily diſſolved: the fixed oils are in general mild; while the volatile are acrid, and even cauſtic. It appears nevertheleſs that the oily principle is the ſame in both; but it is combined with mucilage in the fixed oils, and with the ſpiritus rector, or aroma, in the volatile oils. By burning the mucilage of fixed oils by diſtillation, they become more and more attenuated; the ſame may likewiſe be done by means of water, which diſſolves this principle. By diſtilling volatile oil with a ſmall quantity of water, by the gentle heat of a water bath, the aroma is ſeparated; and this may be again reſtored by re-diſtilling it with the odorant plant which originally afforded it.

Volatile oil is uſually found in the moſt odorant part of any plant. In umbelliferous plants it is found in the ſeed; in the geum, the root affords it; and in the labiated plants it is found in the branches and leaves. The ſimilitude between volatile oils and ether, which appears to be merely a combination of oxigene and alcohol, proves that the volatile oils may be nothing but a combination of the fermen-

tefcible

teſcible baſis of ſugar with oxigene. Hence we may form a notion how oil is formed in the diſtillation of mucilage and of ſugar; and we ſhall no longer be ſurpriſed to find that the volatile oils are acrid and corroſive, that they redden blue paper, attack and deſtroy cork, and approach to the properties of acids. We ſhall now proceed to treat of fixed and volatile oils ſeparately.

DIVISION I.

Concerning Fixed Oils.

Moſt of the fixed oils are fluid; but the greater number are capable of paſſing to the ſtate of ſolidity, even by a moderate degree of cold. There are ſome which conſtantly poſſeſs that form in the temperature of our climates; ſuch as the butter of cacao, wax, and the pela of the Chineſe. They all congeal at different degrees of cold. Olive oils become ſolid at 10° below zero of Reaumur; oil of almonds at the ſame degree; but nut-oil does not freeze in our climates.

The fixed oils poſſeſs a very evident degree of unctuoſity, do not mix either with water or alcohol, are volatilized at a degree of heat ſuperior to that of boiling water, and when volatilized they take fire by the contact of an ignited body.

The fixed oils are contained in the kernels of ſhell fruits or nuts; in the pippins, and ſometimes in all the parts of fruits, ſuch as olives and almonds, all whoſe parts are capable of affording them.

The oil is uſually made to flow by expreſſion out of the cellules which contain it; but each ſpecies requires a different management.

1. Olive oil is obtained by expreſſion from the fruit of the olive tree. The proceſs uſed by us is very ſimple. The olive is cruſhed by a mill-ſtone, placed vertically, rolling upon an horizontal plane. The paſte thus formed is ſtrongly preſſed in a preſs; and the firſt oil which comes out is called Virgin Oil. The marc or pulp is then moiſtened with boiling water; the maſs is again preſſed; and the oil which floats upon the water carries with it part of the parenchyma of the fruit, and a great part of the mucilage, from which it is difficultly cleared.

The difference in the kind of olive produces a difference in the oil; but the concurrent circumſtances likewiſe eſtabliſh other differences. If the olive be not ſufficiently ripe, the oil is bitter; if it be too ripe, the oil is thick and glutinous. The method of extracting the oil has a very great influence on its quality. The oil mills are not kept ſufficiently clean; the mill-ſtones, and all the utenſils, are impregnated with a rancid oil, which cannot but communicate its flavour to the new oil. In ſome countries it is uſual to lay the olives in heaps, and ſuffer them to ferment before the oil is drawn. By this management the oil is bad; and this proceſs can only be uſed for oil intended for the lamp or for the ſoap-boiler.

2. Oil of almonds is extracted from that fruit by expreſſion. For this purpoſe dry almonds are put into a coarſe ſack, and agitated rather ſtrongly, to diſengage an acrid powder which adheres to the ſkin. They are then pounded in a marble mortar into a paſte, which is wrapped in a coarſe cloth, and ſubjected to the preſs.

This oil is greeniſh and turbid when freſh, becauſe the action of the preſs cauſes part of the mucilage to paſs through the cloth; as it becomes older it is clearer, but is acrid by the decompoſition of the ſame mucilage.

Some perſons throw almonds into hot water, or expoſe them to ſteam, before they preſs them; but this addition of water diſpoſes the oils to become rancid more ſpeedily.

By this proceſs the oil of all kinds of almonds, nuts, and ſeeds, may be extracted.

3. Linſeed oil is extracted from the ſeed of the plant linum. As this ſeed contains much mucilage, it is torrefied before it is ſubjected to the preſs. This previous treatment gives the oil a diſagreeable empyreumatic flavour; but at the ſame time deprives it of the property of becoming rancid, and renders it one of the moſt drying oils. All mucilaginous ſeeds, all kernels and the ſeeds of henbane and of the poppy, ought to be treated in the ſame manner.

If a fat oil be diſtilled in a proper apparatus of veſſels, the product is, phlegm; an acid; a fluid or light oil, which becomes thicker towards the end; much hydrogenous gas, mixed with carbonic acid; and a coaly reſidue, which affords no alkali. I have obſerved that the volatile oils afford more hydrogenous gas, and the fixed more carbonic acid: this laſt product depends on the mucilage. By diſtilling the ſame oil repeatedly, it is more and more attenuated, becomes very limpid and very volatile, with the only difference that it has acquired the peculiar odour communicated by the fire. The volatilization of the oil may be accelerated by diſtilling it from an argillaceous earth; by this means it is in a ſhort time deprived of its colouring part: and the heavy oils which afford bitumens, when diſtilled once or twice from clay alone, ſuch as that of Murviel, are rendered perfectly colourleſs. The ancient chemiſts prepared their *oleum philoſophorum* by diſtilling oil from a brick previouſly impregnated with it.

1. Oil eaſily combines with oxigene. This combination is either ſlow or rapid. In the firſt caſe, rancidity is the conſequence; in the ſecond, inflammation.

Fixed oil expoſed for a certain time to the open air, abſorbs the oxigenous gas, and acquires a peculiar odour of fire, an acrid and burnt taſte, at the ſame time that it becomes thick and coloured. If oil be put in contact with oxigene in a bottle, it becomes more ſpeedily rancid, and the oxigene is abſorbed. Scheele obſerved the abſorption of a portion of the air before the theory was well aſcertained. Oil is not ſubject to alteration in cloſed veſſels.

It ſeems that oxigene, combined with the mucilage, conſtitutes rancidity; and that, when combined with the oil itſelf, it forms drying oil.

The rancidity of oils is therefore an effect analogous to the calcination or oxidation of metals. It eſſentially depends on the combination of pure air with the extractive principle, which is naturally united with the oily principle.

ciple. We may carry this inference to demonſtration, by attending to the proceſſes uſed to counteract or prevent the rancidity of oils.

A. When olives are prepared for the table, every endeavour is uſed to deprive them of this principle, which determines their fermentation; and for this purpoſe various methods are uſed. In ſome places they are macerated in boiling water, charged with ſalt and aromatics; and, after twenty-four hours digeſtion, they are ſteeped in clear water, which is renewed till their taſte is perfectly mild. Sometimes nothing more is done than to macerate the olives in cold water; but they are frequently macerated in a lixivium of quick-lime and wood aſhes, after which they are waſhed in clear water. But in whatever manner the preparation is made, they are preſerved in a pickle charged with ſome aromatic plant, ſuch as coriander and fennel. Some perſons preſerve them whole; others ſplit them, for the more complete extraction of their mucilage, and in order that they may be more perfectly impregnated with the aromatics.

All theſe proceſſes evidently tend to extract the mucilaginous principle, which is ſoluble in water, and by this means to preſerve the fruit from fermentation. When the operation is not well made, the olives ferment and change. If olives be treated with boiling water, to extract the mucilage, before they are ſubmitted to the preſs, a fine oil will be obtained, without danger of rancidity.

B. When the oil is made, if it be ſtrongly agitated in water, the mucilaginous principle is diſengaged; and the oil may be afterwards preſerved for a long time without change. I have preſerved oil of the marc of olives, prepared in this manner, for ſeveral years, in open bottles, without any alteration.

C. The torrefaction to which ſeveral mucilaginous ſeeds are ſubjected before the extraction of the oil, renders them leſs ſuſceptible of change, becauſe the mucilage has been deſtroyed.

D. M. Sieffert has propoſed to ferment oils with apples or pears, in order to deprive rancid oils of their acrimony. By this means they are cleared of the principle which had combined with them, but now becomes attached to other bodies.

Mucilage may therefore be conſidered as the ſeed of fermentation.

When the combination of the pure air is favoured by the volatilization of the oil, inflammation and combuſtion are then the conſequence. To carry this combination into effect, the oil muſt be volatilized by the application of a heated body; and the flame which is produced is then ſufficient to maintain the degree of volatility, and ſupport the combuſtion. When a current of air is cauſed to paſs through the middle of the wick and the flame, the great quantity of oxigene which muſt then neceſſarily paſs, occaſions a more rapid combuſtion. Hence it is that the light is ſtronger, and without ſmoke: for this is deſtroyed and conſumed by the violent heat which is excited.

The lamps of Palmer are likewiſe entitled to our particular attention. By cauſing the rays to paſs through a liquor coloured blue, he perfectly imitates the light of the day, which proves that the artificial rays require to be mixed with the blue, to imitate the natural: and the ſolar rays which paſs through the atmoſphere, may owe their colour to their combination with the blue colour which appears to predominate in the air.

If water be projected upon oil in a ſtate of inflammation, it is known that extinction does not happen, becauſe the water is decompoſed in this experiment. If the product of the combuſtion of oil be collected, much water is obtained, becauſe the combination of its hydrogene with oxigene produces that fluid.

Mr. Lavoiſier has proved that one pound of olive oil contains,

Coal or carbone, 12 ounces, 5 gros, 5 grains;
Hydrogene, - 3 — 2 — 67.

The art of rendering oils drying, likewiſe depends on the combination of oxigene with the oil itſelf. For this purpoſe, nothing more is required than to boil it with oxides. If an oil be heated upon the red oxide of mercury, a conſiderable ebullition enſues, the mercury is reduced, and the oil becomes very drying: this is an obſervation of Mr. Puymaurin. The oxides of lead or copper are commonly uſed for this purpoſe. An exchange of principles takes place in this operation; the mucilage combines with the metal, while the oxigene unites with the oil.

Oil may likewiſe be combined with the metallic oxides by double affinity, after the manner of Berthollet. For this purpoſe a ſolution of ſoap is poured into a metallic ſolution. By this means a ſoap of a green colour is prepared with a ſulphate of copper; and, with that of iron, a ſoap of a deep brown colour, of conſiderable intenſity.

It appears that, in the combination of fixed oils with the oxides of lead, a ſubſtance is diſengaged, and ſwims at the top, which Scheele called the Sweet Principle, and ſeems to be ſimply mucilage.

Oil combines with ſugar, and affords a kind of ſoap, which may be eaſily diffuſed in water, and kept ſuſpended. The trituration of almonds with ſugar and water, forms the lac amygdale, orgeat, and other emulſions. Combinations of this kind exiſt ready formed in the vegetable kingdom.

3. Oil unites readily with alkalis; and the reſult of this union is the well-known compound, ſoap. To this effect, pot-aſh or pure alkali may be triturated with oil, and the mixture concentrated by fire. The medicinal ſoap is made with oil of ſweet almonds, and half its weight of pot-aſh or cauſtic alkali. The ſoap becomes hard by ſtanding.

To make the ſoap of commerce, one part of good ſoda of Alicant muſt be boiled with two of quicklime, in a ſufficient quantity of water. The liquor is then to be ſtrained through a cloth, and evaporated to that degree, that a phial which contains eight ounces of pure water, may hold eleven of the ſaline ſolution, which is uſually called Soap Lye or Lees. One part of this lixivium, and two of oil, boiled together, till upon trial with a ſpatula it eaſily ſeparates, and ſoon coagulates, form ſoap.

In moſt manufactories the lixivium is prepared without heat. Equal volumes of pounded ſoda of Alicant, and quicklime previouſly ſlaked, are mixed together. Water is thrown on this mixture, which filters through, and is conveyed into a proper veſſel. Water is poured on till it paſſes through without acquiring any more ſalt. In this way theſe kinds of lyes are obtained, which differ in ſtrength; that which paſſes firſt is the ſtrongeſt, and the laſt is almoſt mere water. Theſe are afterwards mixed with oil in boilers, where the mixture is favoured by heat. The weak lye is firſt added, and afterwards gradually the ſtronger; and the ſtrongeſt is not added till towards the end of the proceſs.

To make the ſoap marbled, they make uſe of ſoda in the maſs, blue copperas, cinnabar, &c. according to the colour deſired.

A liquid green or black ſoap is likewiſe made by boiling the lixivium of ſoda, pot-aſh, or even wood-aſhes, with the marc of the oils of olive, of nuts, or of nape; or with fat, or fiſh oil, &c. The black ſoap is made in Picardy, and the green in Holland. The Marquis de Bouillon has propoſed to make ſoaps with animal fat.

At Aniane, and in the neighbourhood of Montpellier, a ſoft ſoap is prepared with a cauſtic lixivium of wood-aſhes, and the oil of the marc of olives.

If ſoap be expoſed to diſtillation, the reſult is water, oil, and much ammoniac; and there remains in the retort a large quantity of the alkali uſed in the fabrication of the ſoap. The ammoniac which is produced in this experiment, appears to me to ariſe from the combination of the hydrogenous gas of the oil with the nitrogene, a conſtituent principle of the fixed alkali.

Soap is ſoluble in pure water; but it forms curds, and is decompoſed in water abounding with ſulphates: becauſe the ſulphuric acid ſeizes the alkali of the ſoap; while the earth combines with the oil, and forms a ſoap which ſwims at the ſurface.

Soap is likewiſe ſoluble in alcohol by the aſſiſtance of a gentle heat; and forms the eſſence of ſoap, or opodeldoc, which may be ſcented at pleaſure.

Soaps are capable of combining with a larger quantity of oil, and rendering it ſoluble in water. Hence their property of cleanſing cloths, linens, &c. They are uſed as deobſtruents in medicine.

4. The fixed oils unite likewiſe with acids. Meſſrs. Achard, Cornette, and Macquer, have attended to theſe combinations. Achard gra-

dually adds the concentrated ſulphuric acid to the fixed oil; the mixture being triturated, a maſs is obtained which is ſoluble in water and in alcohol.

The fuming nitric acid immediately turns the fixed oils black, and ſets fire to ſuch as are drying. It is in this caſe decompoſed with a rapidity ſo much the greater, as the oil has a greater affinity with the oxigene. On this account it is that the inflammation of the drying oils is more eaſily effected than that of the others.

Thoſe acids whoſe conſtituent parts adhere moſt ſtrongly together, have but a very feeble action on oils; a circumſtance which proves that the effect of acids upon oils is principally owing to the combination of their oxigene.

It is by virtue of this ſtrong affinity of oils with oxigene, that they poſſeſs the power of reviving metals. The oxigene then quits the metal, and unites with the oils, which become thick and coloured. It likewiſe follows from hence that drying oils ought to be preferred for this uſe; and we find that practice agrees with theory in this reſpect.

DIVISION II.

Concerning Volatile Oils.

Fixed oil is combined with mucilage, volatile oil with the ſpiritus rector, or aroma; and it is this combination or mixture which conſtitutes the difference between them. The volatile oils are characterized by a ſtrong ſmell, more or leſs agreeable; they are ſoluble in alcohol and have a penetrating and acrid taſte. All the aromatic plants contain volatile oil, excepting thoſe whoſe ſmell is very tranſient, ſuch as jaſmin, violets, lilies, &c.

The volatile oil is ſometimes diſtributed through the whole plant, as in the Bohemian angelica; ſometimes it exiſts in the bark, as in cinnamon. Balm, mint, and the greater abſinthe, contain their oils in the ſtem and leaves; elicampane, the iris of Florence, and the caryophyllata, in the root. All the reſinous trees contain it in their young branches; roſemary, thyme, and wild thyme, contain their eſſential oils in their leaves and buds; lavender and the roſe, in the calyx of their flowers; camomile, lemon, and orange trees, in the petals. Many fruits contain it through their whole ſubſtance, ſuch as pepper, juniper, &c. Oranges and lemons in the zeſt and peeling which incloſe them. The ſeeds of umbelliferous plants, ſuch as aniſe and fennel, have the veſicles of eſſential oil arranged along the projecting lines upon their ſkin: the nutmeg tree contains its eſſential oil in the nut itſelf.—See *L'Introduction à l'Etude du Regne Veg. par M. Buquet*, p. 209—212.

The quantity of volatile oil varies according to the ſtate of the plant. Some afford moſt when green, others when dry; but the latter conſtitute the ſmalleſt number. The quantity likewiſe varies according to the age of the plant, the ſoil, the climate, and the time of extraction.

The volatile oils likewiſe differ in their conſiſtence. Some are very fluid, as thoſe of lavender, roſemary, and rue; the oils of cinnamon and ſaſſafras are thicker: there are ſome which conſtantly preſerve their fluidity; others which become concrete by the ſlighteſt impreſſion of cold, as thoſe of aniſeed and fennel: others again poſſeſs the concrete form, ſuch as thoſe of roſes, of parſley, and of elicampane.

The volatile oils likewiſe vary in their colour. The oil of roſes is white; that of lavender of a light yellow: that of cinnamon of a brown yellow; the oil of camomile is of a fine blue; that of millefoil, of a ſea-green; that of parſley, green, &c.

The weight is likewiſe different in the different kinds. The oils of our climates are in general light, and ſwim upon water; others are nearly of the ſame weight; and others are heavier, ſuch as the oils of ſaſſafras and of cloves.

The ſmells of eſſential oils vary according to thoſe of the plants which produce them.

The taſte of the volatile oils in general is hot; but the taſte of the plant does not always influence that of the oil: for example, the oil of pepper has no acrimony, and that which is obtained from wormwood is not bitter.

We are acquainted with two methods of extracting the volatile oils—expreſſion and diſtillation.

1. Thoſe oils which are, as it were, in a naked ſtate, and contained in projecting and viſible receptacles, are obtained by expreſſion. Such are thoſe of citrons, oranges, cedrat, and bergamotte; the oil iſſues out of the ſkin of theſe fruits when preſſed. It may therefore be procured by ſtrong preſſure of the peeling againſt an inclined glaſs. In Provence and in Italy they are raſped; by which means the veſicles are torn, and the oil flows into the veſſel deſtined to receive it: this oil ſuffers the paren-

chyma which goes along with it to ſubſide, and becomes clear by ſtanding.

If a lump of ſugar be rubbed againſt theſe veſicles, it imbibes the volatile oils; and forms an oleo-ſaccharum, ſoluble in water, and very proper to give an aromatic flavour to certain liquids.

2. Diſtillation is the method moſt commonly uſed in the extraction of volatile oils. For this purpoſe, the plant or fruit which contains the oil is placed in the boiler or body of the alembic. A quantity of water is then poured in, ſufficient to cover the plant, and the water is heated to ebullition. The oil which riſes with this degree of heat, comes over with the water, and is collected at the ſurface in a particular receiver, called the Italian receiver, which ſuffers the ſurplus of water to eſcape by a ſpout iſſuing from the belly of the veſſel, whoſe orifice is lower than that of the neck of the receiver; ſo that by this means the oil is collected in the neck, without a poſſibility of its eſcaping.

The water which paſſes over in diſtillation is more or leſs charged with oil, and the odorant principle of the plant, and forms what is known by the name of Diſtilled Water. Theſe waters ought to be returned again into the cucurbit, when the ſame kind of plant is again diſtilled;

becauſe, being ſaturated with oil, and the aromatic principle, they contribute to augment the ulterior product.

When the oil is very fluid or very volatile, it is neceſſary to annex a worm pipe to the alembic, and to have the precaution of keeping the water at a very cold temperature: but when, on the contrary, the oil is thick, the worm pipe muſt be removed, and the water of the refrigeratory kept at a moderate temperature. In the firſt way, the oils of balm, mint, ſage, lavender, camomile, &c. may be diſtilled; and, by the ſecond, the oils of roſes, of elicampane, of parſley, of fennel, of cumin, &c.

The oil of cloves may likewiſe be extracted by diſtillation per deſcenſum, which is determined by applying the fire above the material.

Volatile oils are very ſubject to be adulterated, either by mixture with fat oils, or with other eſſential oils, ſuch as that of turpentine, which is cheaper; or by mixing them with alcohol. In the firſt caſe the fraud is eaſily detected— 1. By diſtillation, becauſe volatile oils riſe at the heat of boiling water. 2. By ſoaking paper with a ſpot or trace of the mixture, and expoſing it to a degree of heat ſufficient to drive off the volatile oil. 3. By means of alcohol, which becomes turbid and milky by the inſolubility of the fixed oil.

The volatile oils which have a very ſtrong ſmell, ſuch as thoſe of thyme and lavender, are often ſophiſticated by oil of turpentine. In this caſe the fraud may be diſcovered by ſoaking a ſmall piece of cotton in the mixture, and leaving it expoſed to the air a ſufficient time for the ſmell of the good oil to be diſſipated, and leave only that of the adulteration. The ſame end may be anſwered by rubbing a ſmall quantity of the mixture on the hand, in which the peculiar ſmell of oil of turpentine is developed. Theſe oils are likewiſe falſified by digeſting the plant in oil of olive before diſtillation. In this manner the oil of camomile is prepared.

The very light oils, ſuch as thoſe of cedrat or bergamotte, are often mixed with a ſmall quantity of alcohol. This fraud is eaſily detected by the addition of a few drops of water, which immediately become white, becauſe the alcohol abandons the oil to unite with the water.

The volatile oils are capable of uniting with oxigene, with alkalis, and with acids.

1. Volatile oils abſorb oxigene with greater facility than the fixed oils. They become coloured by the abſorption, grow thicker, and paſs

to the ſtate of reſin; and when they are thickened to this point, they are no longer capable of fermenting, but ſecure from all putrefaction ſuch bodies as are penetrated and well impregnated with them. On this is founded the theory of embalming.—The action of acids upon theſe oils, cauſes them to paſs to the ſtate of reſin; and there is no other difference between volatile oil and reſin, than that which ariſes from this addition of oxigene.

All the oils, when they aſſume the character of reſin by this combination of oxigene, let fall needle-formed cryſtals of camphor. Mr. Geoffroy has obſerved them in the oil of feverfew, marjoram, and turpentine. Acad. 1721, p. 163.

When the oil is changed by the combination of oxigene, it gradually loſes its ſmell and volatility. To reſtore this oil to its original ſtate, it is diſtilled. A thick matter remains in the diſtilling veſſel, which conſiſts of reſin perfectly formed, and is thus ſeparated from the oil, which has not yet undergone the ſame alteration.

2. The habitudes of acids are not the ſame with all volatile oils. 1. The concentrated ſulphuric acid thickens them; but, if it be diluted, it forms ſavonules. 2. The nitric acid,

when concentrated, inflames them; but, when diluted, it cauſes them gradually to paſs to the ſtate of reſin. Borrichius appears to have been the firſt who inflamed oil of turpentine with the ſulphuric acid, without the nitric acid. Homberg repeated this delicate experiment with the other volatile oils. The inflammation of oils is ſo much the more eaſily effected, as the oil is more drying or greedy of oxigene, and the acid more eaſily decompoſed. 3. The muriatic acid reduces oils to the ſaponaceous ſtate, but the oxigenated muriatic acid thickens them.

3. Starkey appears to have been one of the firſt who attempted to combine a volatile oil with a fixed alkali. His proceſs is long and complicated, like thoſe of the alchemiſts; and the combination it afforded was known by the name of Starkey's Soap. The proceſs of this chemiſt was ſo long merely becauſe he uſed the carbonate of pot-aſh, or mild vegetable alkali; but if ten parts of cauſtic alkali, or *lapis cauſticus*, be triturated hot with eight parts of oil of turpentine, the ſoap is inſtantaneouſly formed, and becomes very hard. This is the proceſs of Mr. Geoffroy.—Acad. des Sciences, ann. 1725.

Concerning Camphor.

Camphor is obtained from a ſpecies of laurel which grows in China and Japan. Some travellers affirm that the old trees contain it ſo abundantly, that on ſplitting the trunk it is found in large tears, ſo pure as to have no need of rectification. To extract the camphor, the roots of the trees are uſually choſen; or, in want of theſe, all the other parts of the tree. Theſe are put, together with water, into an iron alembic, which is covered with its head. The capital is fitted up internally with cords of rice ſtraw, the joinings are luted, and the diſtillation proceeded upon. Part of the camphor ſublimes, and attaches itſelf to the ſtraw within the head; while another portion is carried into the receiver with the water. The Hollanders purify camphor by mixing an ounce of quicklime with every pound of the ſubſtance, and ſubliming it in large glaſs veſſels.

Camphor, thus purified, is a white concrete cryſtalline ſubſtance, of a ſtrong ſmell and taſte, ſoluble in alcohol, burning with a white flame, and leaving no reſidue: reſembling volatile oils in many reſpects, but differing from them in certain properties; ſuch as that of burning without

out a reſidue; of diſſolving quietly, without decompoſition or alteration, in acids; and of being volatilized by a gentle heat, without change of its nature.

Camphor is obtained by diſtillation from the roots of zedoary, thyme, roſemary, ſage, the inula helenium, the anemony, the paſque flower or pulſatilla, &c. And it is to be obſerved, that all theſe plants afford a much greater quantity of camphor when the ſap has been ſuffered to paſs to the concrete ſtate, by a deſiccation of ſeveral months. Thyme and peppermint, ſlowly dried, afford much camphor; whereas the freſh plants afford volatile oil: moſt of the volatile oils, in paſſing to the ſtate of reſin, alſo let fall much camphor. Mr. Achard has likewiſe obſerved that a ſmell of camphor was diſengaged when he treated the volatile oil of fennel with acids. The combination of the diluted nitric acid with the volatile oil of aniſe, afforded him a large quantity of cryſtals, which poſſeſſed moſt of the properties of camphor. He obtained a ſimilar precipitate by pouring the vegetable alkali upon vinegar ſaturated with the volatile oil of angelica.

From all theſe facts it appears, that the baſe of camphor forms one of the conſtituent principles of ſome volatile oils; but it is in the liquid ſtate, and does not become concrete but by combining with oxigene.

Camphor is capable of cryſtallization, according to Mr. Romieu, whether in ſublimation, or when it is ſlowly precipitated from alcohol, or when alcohol is ſuperſaturated with it; it precipitates in ſlender filaments, cryſtallizes in hexagonal blades attached to a common axis, and it ſublimes in hexagonal pyramids or in polygonal cryſtals.

Camphor is not ſoluble in water; but it communicates its ſmell to that fluid, and burns on its ſurface. Romieu has obſerved that ſmall pieces of camphor, of one-third or one-fourth of a line in diameter, being placed on the ſurface of pure water in a glaſs, have a rotatory motion: and this appears to be an electrical phænomenon; for the motion ceaſes if the water be touched with a conducting ſubſtance; but continues if it be touched with an inſulating body, ſuch as glaſs, ſulphur, or reſin. Bergen has obſerved that camphor does not turn upon hot water.

Acids diſſolve camphor without producing any alteration in it, or becoming themſelves decompoſed: the nitric acid diſſolves it quietly; and this ſolution has been called Oil of Camphor. Camphor precipitated from its ſolution acids by the addition of alkalis, is heavier, harder, and much leſs combuſtible, according to the experiments of Mr. Koſegarten. By diſtilling the nitric acid ſeveral times from this ſubſtance, it acquires all the properties of an acid which cryſtallizes in parallelopipedons. To obtain the camphoric acid, nothing more is required than to diſtil the acid at ſeveral times from the camphor, and in a large quantity. Mr. Koſegarten diſtilled the nitric acid eight times from camphor, and obtained a ſalt cryſtallized in parallelopipedons, which reddened ſyrup of violets, and the tincture of turnſole. Its taſte is bitter; and it differs from the oxalic acid in not precipitating lime from the muriatic acid.

With potaſh it forms a ſalt which cryſtallizes in regular hexagons.

With ſoda it affords irregular cryſtals.

With ammoniac it forms cryſtalline maſſes, which exhibit cryſtals in needles and in priſms.

With magneſia it produces a white pulverulent ſalt, which may again be diſſolved in water.

It diſſolves copper, iron, biſmuth, zinc, arſenic, and cobalt. The ſolution of iron affords a yellowiſh white powder, which is inſoluble.

This acid forms, with mangeneſe, cryſtals whoſe planes are parallel, and in ſome reſpects reſemble baſaltes.

The

The camphoric acid, or rather the radical of this acid, exiſts in ſeveral vegetables; ſince camphor may be extracted from the oils of thyme, of cinnamon, of turpentine, of mint, of feverfew, of ſaſſafras, &c. Mr. Dehne has obtained it from the paſque flower, or pulſatilla; and Cartheuſer has indicated ſeveral other plants which contain it.

Alcohol readily diſſolves it, and it may be precipitated by water alone: this ſolution is known in pharmacy by the name of Camphorated Spirit of Wine; or Camphorated Brandy, when brandy is the ſolvent.

The fixed and volatile oils likewiſe diſſolve each other by the aſſiſtance of heat; the ſolutions let fall cryſtals in vegetation, ſimilar to thoſe which are formed in the ſolutions of ſal ammoniac, compoſed of very fine filaments adhering to a middle part. This obſervation was made by Mr. Romieu, Acad. des Sciences, 1756.

Camphor is one of the beſt remedies which the art of medicine poſſeſſes. When applied to inflammatory tumours it is reſolvent; and, internally taken, it is antiſpaſmodic, eſpecially when diſſolved in brandy. It is given in Germany and in England in the doſe of ſeveral drams per day; but in France our timid phyſicians do not preſcribe it in a larger doſe than a few grains. It mitigates heat in the urinary paſſage. It is given triturated with yolk of egg, ſugar, &c.

It has likewiſe been ſuppoſed that its ſmell deſtroyed or drove away moths, and other inſects, which feed upon cloth, &c.

ARTICLE III.

Concerning Reſins.

The name of Reſin is uſed to denote inflammable ſubſtances ſoluble in alcohol, uſually affording much ſoot by their combuſtion; they are likewiſe ſoluble in oil, but not all in water.

All the reſins appear to be nothing elſe but oils rendered concrete by their combination with oxigene. The expoſure of theſe to the open air, and the decompoſition of acids applied to them, evidently prove this concluſion.

Reſins in general are leſs ſweet than the balſams. They afford more volatile oil, but no acid, by diſtillation.

There are ſome among the known reſins which are very pure, and perfectly ſoluble in alcohol, ſuch as the balm of Mecca and of Copahu, turpentines, tacamahaca, elemi; others are leſs pure, and contain a ſmall portion of extract, which renders them not totally ſoluble in alcohol; ſuch are maſtic, ſandarach, guaiacum, laudanum, and dragon's blood.

1. The balſam of Mecca is a fluid juice which becomes thick and brown by age. It flows from inciſions made in the amaris opobalſamum. It is known by the different names of Balm of Júdea, of Egypt, of Grand Cairo, of Syria, of Conſtantinople, &c.

Its ſmell is ſtrong, and inclining to that of lemons; its taſte is bitter and aromatic.

This balſam, diſtilled by the heat of boiling water, affords much volatile oil.

It is balſamic; and is given incorporated with ſugar, or mixed with the yolk of egg. It is aromatic, vulnerary, and healing.

2. The balſam of Copahu flows from a tree called Copaiba, in South America, near Tolu. It affords the ſame products, and poſſeſſes the ſame virtues, as the foregoing.

3. The turpentine of Chios flows from the turpentine tree, which affords the piſtachios. It is fluid, and of a yellowiſh white colour inclining to blúe.

This plant grows in Cyprus, at Chios, and is common in the ſouth of France. The turpentine is obtained only from the trunk and large branches. Inciſions are made firſt at the lower part of the tree, and afterwards by degrees higher up.

This turpentine, diſtilled on the water-bath, without addition, affords a very white, very limpid, and very fragrant volatile oil: a more ponderous oil may be extracted at the heat of boiling water; and the reſidue, which is called Boiled Turpentine, affords by diſtillation, in the reverberatory furnace, a weak acid, a ſmall quantity of brown conſiſtent oil, and much coal.

The turpentine of Chios is very rare in commerce. Venice turpentine is extracted from the larix: its colour is a bright yellow, its conſiſtence limpid, its ſmell ſtrong and aromatic, and its taſte bitter.

The tree which affords it is that which affords manna. Holes are bored during the ſummer near the bottom of the trunks of theſe trees, into which ſmall gutters or tubes are inſerted, to convey the juice into veſſels intended to receive it. The reſin is obtained only from trees in full vigour; the old trees very often have conſiderable depoſitions of reſin in their trunks.

This turpentine affords the ſame principles as that of Chios.

It is uſed in medicine as a detergent for ulcers in the lungs, kidneys, &c. either incorporated with ſugar, or mixed with the yolk of an egg, to render it more miſcible with aqueous potions. The ſoap of Starkey, which we have ſpoken of under the article of Volatile Oils, is made with this turpentine.

The reſin known in commerce by the name of Straſburgh Turpentine, is a reſinous juice of the conſiſtence of a fixed oil, of a yellowiſh white colour, a bitter taſte, and a more agreeable ſmell than the preceding reſins.

It flows from the yew-leaved fir, which is very common in the mountains of Switzerland. This reſin is collected in bliſters, which appear beneath the bark in the ſtrong heats of ſummer. The peaſants pierce theſe veſicles with the point of a ſmall horn, which becomes filled with the juice, and is from time to time emptied into a larger veſſel.

The balm of Canada differs from the turpentine of the fir in its ſmell only, which is more pleaſant. It is obtained from a ſpecies of fir which grows in Canada.

Oil of turpentine is more particularly uſed in the arts. It is the great ſolvent for all reſins; and, as it evaporates, it leaves them applied to the ſurface of bodies on which the mixture has been ſpread. As reſins are the baſis of all varniſhes, alcohol and oil of turpentine muſt be the vehicles or ſolvents.

4. Pitch is a reſinous juice, of a yellow colour, more or leſs inclining to brown. It is afforded by a fir named Picea or Epicea. Inciſions are made through the bark; and the wound is renewed from time to time, as the lips become callous. A vigorous tree often affords forty pounds.

Pitch melted, and expreſſed through bags of cloth, is rendered purer. It is packed in barrels, by the name of White Pitch, or Burgundy Pitch.

White pitch, mixed with lamp-black, forms black pitch.

White pitch kept in fuſion becomes dry. The deſiccation may be facilitated with vinegar, and leaving it for a time over the fire. It then becomes very dry, and is called Colophony.

Lamp-black is the ſoot of burned pitch. It is likewiſe prepared by collecting the ſoot of pit-coal.

5. Galipot is a concrete reſinous juice, of a yellowiſh white colour and ſtrong ſmell. This juice comes from Guienne, where it is afforded by two ſpecies of pine, the *pinus maritima major, et minor*.

When theſe trees have acquired a certain ſize, a hole or notch is cut through the bark, near the bottom of the trunk. The reſin iſſues out, and flows into veſſels placed beneath to receive it. Care is taken to keep the wound open, and to renew it. The reſin flows during the ſummer; but that which iſſues out during the ſpring, autumn, and winter, dries againſt the tree.

The pine likewiſe affords tar, and the oil called *huile de Cade*. For this purpoſe the wood of the trunk, branches, and roots, is heaped together and covered with turf, over which a fire is lighted, as if to convert them into charcoal. The oil which is diſengaged, not being at liberty to eſcape, falls to the bottom into a channel or gutter, which conveys it into a tub. The moſt fluid part is ſold under the name of *huile de Cade;* and the thicker part is the tar uſed for paying or painting the parts of ſhipping and other veſſels.

The combination of ſeveral reſins, coloured by cinnabar and minium, forms ſealing-wax. To make the wax, take half an ounce of gum-lac, two drams of turpentine, the ſame quantity of colophony, one dram of cinnabar, and the ſame quantity of minium. The lac and the colophony are to be firſt fuſed, after which the turpentine is to be added, and laſtly the colouring matters.

6. Maſtic has the form of white tears of a farinaceous appearance, having little ſmell, and a bitter aſtringent taſte. Maſtic flows naturally

from the tree, but its produce is accelerated by inciſions. The leſſer turpentine tree, and the lentiſcus, afford that which is met with in commerce.

Maſtic affords no volatile oil when diſtilled with water. It is almoſt totally ſoluble in alcohol.

This reſin is uſed in fumigations. It is chewed, to ſtrengthen the gums; and it forms the baſis of ſeveral drying varniſhes.

7. Sandarach is a concrete reſinous juice, in dry white tranſparent tears, of a bitter and aſtringent taſte. It is obtained from moſt ſpecies of the juniper, and is found between the bark and the wood.

Sandarach is almoſt totally ſoluble in alcohol, with which it forms a very white varniſh, that dries ſpeedily. For this reaſon, the reſin itſelf is known by us under the name of Varniſh (*vernis*).

8. Labdanum is a black reſinous juice, dry and friable, of a ſtrong ſmell, and a diſagreeable aromatic taſte. It tranſudes from the leaves and branches of a kind of ciſtus, which grows in the iſland of Candia. Tournefort, in his Voyage to the Levant, informs us that when the air is dry, and the reſin iſſues out of the pores of the ciſtus, the peaſants ſtrike all the

parts of theſe trees with a kind of whip, made of ſeveral thongs of leather, fixed to the end of a ſtaff. The juice adheres to the leather, and is cleared off with a knife. This is pure labdanum, and is very rare. That which is known by the name of *labdanum in tortis*, is mixed with a very fine ferruginous ſand, for the purpoſe of increaſing its weight.

9. Dragon's blood is a reſin of a deep red in the maſs; but brighter when in powder. It has neither taſte nor ſmell.

It is obtained from the *drakena*, in the Canary iſlands, from which it flows in tears during the dog-days. It is alſo obtained from the ptero-carpus draco. The parts are expoſed to the vapour of hot water; the juice iſſues out in drops, which are collected and wrapped up in the leaves of reeds.

The dragon's blood of the ſhops, which has the form of flattened orbicular loaves, is a compoſition of various gums, to which this form is given, after they have been coloured with a ſmall quantity of dragon's blood.

Dragon's blood is ſoluble in alcohol: the ſolution is red: the reſin itſelf may be precipitated of the ſame colour.

This reſin is uſed in medicine as an aſtringent.

ARTICLE IV.

Concerning Balſams.

Some authors define balſams to be fluid inflammable ſubſtances; but there are ſome which are dry. Others again give this name to the moſt fragrant among the reſins. M. Bucquet has confined this denomination to ſuch reſins only as have a ſweet flavour, capable of being communicated to water; and which more eſpecially contain fragrant acid and concrete ſalts, which may be ſeparated by decoction or ſublimation. It appears therefore that theſe ſubſtances contain a principle not found in reſins, which, combining with oxigene, forms an acid; while the oil, ſaturated with the ſame air, forms the reſin. This acid ſalt is ſoluble in water and alcohol. As the chemical analyſis points out a ſufficiently ſtriking difference between balſams and reſins, we think it proper to treat them ſeparately.

The ſubſtances called Balſams are therefore reſins united with a concrete acid ſalt. We are acquainted with three principal kinds; viz. benzoin, the balſam of Tolu, and the ſtorax calamita.

1. Benzoin is a coagulated juice, of a pleaſant fragrant ſmell, which becomes ſtronger by friction and heat.

Two varieties of this ſubſtance are known; the benzoë amygdaloides, and the common benzoin. The firſt is compoſed of the moſt beautiful tears of this balſam, connected together by a gluten of the ſame nature; but browner, and of the aſpect of nutmegs in its fracture. The ſecond is merely the juice itſelf, without any mixture of theſe fine and very pure tears. It comes to us from the kingdom of Siam, and the iſland of Sumatra; but we do not know the tree that affords it *.

Benzoin, laid upon hot coals, fuſes, ſpeedily takes fire, and emits a ſtrong aromatic ſmell. But if it be merely heated, without ſetting it on fire, it ſwells up, and emits a more pleaſant though leſs powerful ſmell.

Benzoin pounded, and boiled in water, affords an acid ſalt, which cryſtallizes in long needles by cooling. This ſalt may alſo be extracted by ſublimation. It riſes by a degree of heat even leſs than that which is required to raiſe the oil of benzoin; and this is the ſubſtance called Flowers of Benzoin, or the Sublimed Acid of Benzoin.

---

[*] For a drawing and deſcription of this tree, conſult Dryander, in the Phil. Tranſ. vol. lxxvii. No. 31.

zoin. Neither of theſe proceſſes is œconomical; and in the preparation of theſe articles, in the large way, I begin by diſtilling the benzoin, and cauſe all the products to paſs confounded together into a capacious receiver. I then boil the product in water, and by this means I obtain a much greater quantity of the ſalt of benzoin: becauſe, in this ſtate, the water attacks and diſſolves the whole contents; whereas the moſt accurate trituration will not produce the ſame effect.

The ſublimed acid of benzoin has a very penetrating aromatic ſmell, which excites coughing; more eſpecially if the ſubliming veſſels be opened while yet hot. It reddens the ſyrup of violets, and effervesces with the alkaline carbonates. It unites with earths, alkalis, and metals, and forms benzoates, of which Bergmann and Scheele have given us ſome account.

Alcohol diſſolves benzoin totally, without leaving any reſidue but ſuch foreign impurities as the balſam may happen to contain. It may be precipitated by the addition of water; and then conſtitutes the opake fluid called Lac Virginale.

Benzoin is uſed as an aromatic in medicine; but it is ſeldom uſed in ſubſtance, becauſe of its ſparing ſolubility: its tincture, and volatile acid, are uſed. The latter is a good inciſive medicine to be adminiſtered in pituitous obſtructions of the lungs, the kidneys, &c. It is given in extracts, or diſſolved in water.

Benzoin is employed in fumigations for indolent tumours. The oil is likewiſe an excellent reſolvent. It is applied by friction to members affected with cold rheumatic and paralytic diſorders.

2. The balſam of Tolu, of Peru, or of Carthagena, has a mild and pleaſant ſmell.

It is met with in commerce in two different forms; either in ſhells, or in the fluid ſtate. The coco is ſoftened by boiling water, and the balſam flows out in the fluid form.

The tree which affords it, is the Toluifera of Linnæus. It grows in South America, in the diſtrict called Tolu, between Carthagena and Nombre de Dios.

The fluid balſam affords much volatile oil when diſtilled by the heat of boiling water.

An acid ſalt may be extracted from this balſam, which greatly reſembles that of benzoin, and may be obtained by the ſame proceſſes; but this ſublimed ſalt is commonly brown, becauſe it is ſoiled by a portion of the balſam, which riſes with a leſs heat than benzoin does.

This balſam is ſoluble in alcohol, and may be precipitated by the addition of water.

It is much uſed in medicine, as an aromatic, vulnerary, and antiputreſcent remedy. It is adminiſtered either triturated with ſugar, or mixed with ſome extract. A ſyrup is prepared from it by digeſting it in a gentle heat with ſugar; or by diſſolving it in alcohol, adding ſugar, and ſuffering the alcohol to diſſipate ſpontaneouſly.

It is falſified by macerating the diſtilled oil of benzoin upon the buds of the balm-ſcented poplar, and adding a ſmall quantity of the natural balſam.

Storax or ſtyrax calamita is a juice of a very ſtrong but very pleaſant ſmell. Two varieties are known in commerce: the one in reddiſh clean tears; the other in maſſes of a blackiſh red colour, ſoft and fatty.

The plant which affords it is called the oriental liquid amber. It has been long ſuppoſed to be the ſtyrax folio mali cotonæi C. B. which is known in Provence, in the wood of La Chartreuſe de Montrieu, by the name of Aliboufier; and, according to Duhamel, affords a very odorant juice, which he took for ſtorax.

Its habitudes during analyſis are the ſame as the preceding, and it exhibits the ſame phenomena.

It was formerly brought to us in canes or reeds, whence its name of ſtorax calamita.

Theſe three balſams form the baſe of thoſe fragrant paſtils which are burned in the chambers of the ſick, to conceal or diſguiſe bad ſmells. Theſe balſams are made into maſſes by means of gum; with the addition of charcoal and the nitrate of pot-aſh, to facilitate combuſtion.

ARTICLE V.

Concerning Gum Reſins.

The gum reſins are a natural mixture of extract and reſin. They ſeldom flow naturally from plants, but iſſue out from inciſions made for that purpoſe. They are ſometimes white, as in the tithymalus and the fig-tree; ſometimes yellow, as in the chelidonium: ſo that we may conſider theſe ſubſtances as true emulſions, whoſe conſtituent principles vary in their proportions.

The gum reſins are partly ſoluble in water, and partly in alcohol.

One character of gum reſins is, that they render water turbid in which they are boiled.

This claſs is ſufficiently numerous; but we ſhall only treat of the principal ſpecies, and more eſpecially thoſe which are uſed in medicine.

1. Olibanum, or frankincenſe, is a gum reſin, in tears of a yellowiſh white colour, and tranſparent. Two kinds are known in trade: the male incenſe, in ſmall very pure tears; and the female incenſe, in large and impure tears.

The tree which affords it is not known. Some authors ſuppoſe it to be the cedar with cypreſs leaves.

Olibanum contains three parts of reſinous matter, and one of extract. When it is boiled in water, the ſolution is white and turbid, like that of all the juices of this claſs. When it is freſh, it affords a ſmall quantity of volatile oil.

Olibanum is uſed in medicine as a reſolvent. But its chief uſe is in our temples, where it has been adopted as one of the inſtruments of worſhip of the Divinity.

It is uſed in hoſpitals, to diſguiſe the ſmell of the putrid air which is exhaled. M. Achard has proved that this proceeding has no other effect than that of deceiving the ſenſe of ſmelling.

2. Scammony is of a blackiſh grey colour, a bitter and acrid taſte, and a ſtrong nauſeous ſmell.

Two varieties are met with in commerce; one of which comes from Aleppo, and the other from Smyrna. The firſt is paler, lighter, and more pure; the ſecond is black, heavy, and mixed with foreign ſubſtances.

It is extracted from the convolvulus ſcammonia, principally from the root. For this purpoſe inciſions are made at the head of the root: it is collected in muſcle ſhells. But moſt of that met with in trade is obtained from the roots by expreſſion.

From the reſults of the analyſis of Geoffroy and Cartheuſer, it appears that the proportion of the component parts varies in the different ſpecimens examined. The latter obtained near one-half of extract, whereas the former found only one-ſixth.

Scammony is uſed in medicine as a purgative, in the doſe of ſeveral grains. When triturated with ſugar and almonds, it forms a very agreeable purgative emulſion. When ſoftened by a mixture of the juice of liquorice, or of wild quinces, it forms the diagredium.

3. Gum guttæ has a reddiſh yellow colour: it has no ſmell; but its taſte is acrid and cauſtic. Gum guttæ was brought to Cluſius in 1630. It comes from the kingdom of Siam, from China, and from the iſland of Ceylon, in cylinders of various ſizes. The tree which affords it is called Coddam Pulli. Herman reports, from his own obſervation as an eye-witneſs, that a milky and yellowiſh juice flows from inciſions

made in theſe trees; that this juice becomes thick by the heat of the ſun; and that, when it is in a ſtate fit to be handled, it is formed into large globular maſſes.

Geoffroy has extracted five-ſixths of reſin from gum guttæ. Cartheuſer has aſcribed to it more extractive than reſinous matter.

Gum guttæ is ſometimes uſed as a purgative, in a doſe of a few grains. But the principal uſe of this ſubſtance is in painting, where it is recommended by the beauty of its colour.

4. Aſſa fœtida is met with in tears of a yellowiſh white colour; but moſt commonly in the form of loaves formed by the aggregation of a number of the tears. It has an acrid and bitter taſte, and its ſmell is one of the moſt diſagreeable.

The plant which affords it is called Ferula Aſſa Fœtida.

This plant grows in Perſia; and the juice of its root is obtained by expreſſion, according to Kæmpfer. It is fluid and white when it iſſues from the plant, and it emits an abominable ſmell when recent. This juice loſes its ſmell, and becomes coloured, as it dries. But it ſtill retains ſmell enough to entitle it to the name of Stercus Diaboli.

The Indians find its flavour agreeable; they uſe it for ſeaſoning, and call it the *food of the* *gods:* a proof which evinces, beyond every argument, that taſtes muſt not be diſputed.

Cartheuſer found it to contain one-third of reſin.

It is a ſolvent and diſcutient remedy; and more particularly valuable as a moſt powerful antihyſteric.

5. Aloes is a juice of a red brown colour, and very conſiderable bitterneſs. Three ſpecies are diſtinguiſhed—the ſoccotrine aloes, the hepatic aloes, and the coballine aloes: they differ only in their degree of purity. M. de Juſſieu, who ſaw theſe three varieties prepared at Morviedro in Spain, aſſures us that they are all obtained from the aloë vulgaris. The firſt variety is obtained by making inciſions in the leaves. Time is allowed for its impurities to ſubſide perfectly. The fluid is then decanted from the dregs, and left to become thick; after which it is put into leathern ſacks for ſale, under the name of Soccotrine aloes. A juice of the ſame nature is obtained by expreſſion from the ſame leaves, which, when clarified in the ſame manner, forms the hepatic aloes; and the coballine aloes is obtained by a ſtronger preſſure.

The Soccotrine aloes contains no more than one-eighth of reſin, according to Boulduc. The hepatic aloes contains half its weight.

Aloes is very much uſed in medicine as a purgative, tonic, alterative, and vermifuge.

6. Gum ammoniac is ſometimes met with in ſmall tears, white within, and yellow without. But they are often united in the maſs, reſembling the benzoë amygdaloides.

Its ſmell is fetid; and its taſte acrid, bitter, and rather nauſeous.

This juice comes from the deſerts of Africa, and the plant which affords it is unknown: it is preſumed to be of the claſs of umbelliferous plants, from the figure of the ſeeds found in it.

Gum ammoniac is very much uſed in medicine. It is a very good alterative; and is given in pills, incorporated with ſugar, or in ſome extract. It may even be diſſolved or diffuſed in water: this liquid becomes turbid, and of a yellowiſh white. Gum ammoniac enters into the compoſition of all diſcuſſive plaſters.

Concerning Caoutchouc, or Elaſtic Gum.

Elaſtic gum is one of thoſe ſubſtances which it is difficult to claſs. It burns like reſins; but its ſoftneſs, its elaſticity, and its inſolubility in the menſtruums which uſually diſſolve reſins, do not allow us to claſs it among thoſe bodies.

The tree which affords it is known by the name of Seringa by the Indians of Para. The inhabitants of the province of Eſmeraldas, a province of Quito, call it Hhava; and thoſe of the province of Mainas, Caoutchouc.

Mr. Richard has proved that this tree is of the family of the euphorbia; and Mr. Dorthes has obſerved, that the *coccus* which are covered with a down that reſembles ſmall ſtraws, were covered with a gum very much reſembling the elaſtic gum. Theſe inſects feed on the euphorbium; but thoſe which come from other ſituations afford the ſame juice.

We are indebted to Mr. Condamine for an account, and accurate details, concerning this tree. (Acad. des Sciences, 1751.) This academician informs us, after Mr. Freſneau, engineer at Cayenne, that the caoutchouc is a very lofty tree. Inciſions are made in the bark; and the white juice, which flows out in a more or leſs liquid ſtate, is received in a veſſel placed for that purpoſe. This is applied in ſucceſſive coatings upon a mould of clay, and dried by the fire, or in the ſun. All ſorts of deſigns are traced upon it while ſoft; and, when it is dry, the clay mould is cruſhed, and the pieces ſhaken out.

This gum is very elaſtic, and capable of great extenſion.

When elaſtic gum is expoſed to the fire, it becomes ſoft, ſwells up, and burns with a white flame. It is uſed for illumination, inſtead of candles, at Cayenne.

It is not at all ſoluble either in water or alcohol. But Macquer has aſſured us that ether is its true ſolvent; and upon this property he has inſtituted the art of making bougies for chirurgical uſes of elaſtic gum, by applying this ſolution upon a mould of wax till it is of the requiſite thickneſs.

Mr. Berniard, to whom we are indebted for important obſervations upon this ſubſtance, found only the nitric ether which diſſolved elaſtic gum. Very pure ſulphuric ether did not perceptibly act upon it.

If elaſtic gum be put in contact with a volatile oil, ſuch as that of turpentine, or even if it be expoſed to the vapour of that fluid, it ſwells, ſoftens, and becomes very paſty. It may then be ſpread upon paper, or applied as a varniſh to cloth; but this covering preſerves its adheſive quality, and does not loſe it for a long time. The mixture of volatile oil and alcohol forms a better ſolvent than the pure oil, and the varniſh dries more ſpeedily.

Mr. Berniard has concluded from his experiments that the elaſtic gum is a fat oil, coloured by a matter ſoluble in alcohol, and ſoiled by the ſmoke to which the gum is expoſed in drying.

If linſeed oil be rendered very drying by digeſting it upon the oxides of lead, and it be afterwards applied with a ſmall bruſh upon any ſurface, and dried by the ſun or in the ſmoke, it affords a pellicle of a conſiderable degree of firmneſs, evidently tranſparent, burning like elaſtic gum, and wonderfully elaſtic and extenſible. If this very drying oil be left in a wide ſhallow veſſel, the ſurface becomes thick, and forms a membrane which has the greateſt analogy with the elaſtic gum. A pound of this oil ſpread upon a ſtone, and expoſed to the air for ſix or ſeven months, acquired almoſt all the properties of elaſtic gum. It was uſed to make catheters and bougies; was applied to varniſh balloons, &c.

Some gum reſins are cleared by art of their extractive principle, for the purpoſe of applying them to various uſes. Such is the intention of the proceſs uſed to make bird-lime. This is made from different ſubſtances, as the berries of miſletoe, the fruit of the ſebeſten, &c. But the beſt is that which is made of the bark of the hollyoak. Theſe trees are peeled in the month of June or July; the outer bark is rejected, and the ſecond is boiled in ſpring water for ſeven or eight hours. It is then made into maſſes, which are buried in the ground, and covered with ſtones, for ſeveral layers one over the other. After having previouſly drained off the moiſture, they are ſuffered to ferment for fifteen days, until the matter has acquired the adheſive conſiſtence of paſte. The maſs is then beaten till it becomes capable of being wrought with the hands, or kneaded; after which it is waſhed in a running ſtream. Laſtly, it is placed for three or four days in another veſſel, that it may throw up its ſkum or impurities; in which laſt ſtate it is put into proper veſſels, and kept for uſe.

The following compoſition is likewiſe made uſe of under the name of Bird-Lime. Take one pound of bird-lime, one pound of gooſe-greaſe; add to this one ounce of vinegar, half an ounce of oil, and the ſame quantity of turpentine. Boil the mixture for ſeveral minutes, and heat the maſs when you are deſirous of uſing it as a cement. It may be prevented from freezing in winter, by adding a ſmall quantity of petroleum.

Concerning Varniſh.

The Pere d'Incarville has informed us that the tree which affords the varniſh of China is called Tſi-chou by the Chineſe. This tree is propagated by off-ſets. When the cultivator is deſirous of planting this, he takes a branch, which he wraps up in a maſs of earth, by means of flax. Care is taken to moiſten this earth; the branch puſhes out roots, and is then pruned and tranſplanted. This tree grows to the ſize of a man's leg.

The varniſh is drawn in ſpring. If it be a cultivated tree, it affords three gatherings. It is extracted by inciſions made in the ſpring: and when the varniſh, which is received in ſhells, does not flow, ſeveral hogs briſtles, moiſtened with water or ſpittle, are introduced into the wound, and cauſe it to run. When the tree is exhauſted, the upper part of it is wrapped in ſtraw, which is ſet on fire, and cauſes the varniſh to precipitate to the bottom of the tree, where it flows out of perforations made for that purpoſe.

Thoſe who collect the varniſh ſet out before day-break, and place their ſhells beneath the apertures. The ſhells are not left longer than three hours in their place, becauſe the heat of the ſun would evaporate the varniſh.

The varniſh emits a ſmell which the workmen are very careful to avoid reſpiring. It produces an effect which they call the bud of the Varniſh.

When the varniſh iſſues from the tree, it reſembles pitch. By expoſure to the air it gradually becomes coloured, and is at laſt of a beautiful black.

The juice which flows from inciſions made in the trunk and branches of the thus toxicodendron, poſſeſſes the ſame properties. The tree that grows in our climates affords a white milky fluid, which becomes black and thick by the contact of the air; its colour is the moſt beautiful black: and it would be eaſy to introduce this valuable ſpecies of induſtry into the kingdom, becauſe the tree grows wonderfully well in all climates, and reſiſts the cold of the winter.

To make the varniſh bright, it is evaporated by the ſun; and a body is given to it with hog's gall, and the ſulphate of iron, or martial vitriol.

The Chineſe uſe the oil of tea, which they render drying by boiling it with orpiment, realgar, and arſenic.

The varniſhes moſt uſed in the arts have all of them the reſins for their baſe; and the fundamental facts in this valuable art are reducible to the following principles.

To varniſh any ſubſtance, conſiſts in applying upon its ſurface a covering of ſuch a nature, as ſhall defend it from the influence of the air, and give it a ſhining appearance.

A coat of varniſh ought therefore to poſſeſs the following properties:—1. It muſt exclude the action of the air; becauſe wood and metals are varniſhed to defend them from decay and ruſt. 2. It muſt reſiſt water; for otherwiſe the effect of the varniſh could not be permanent. 3. It ought not to alter ſuch colours as are intended to be preſerved by this means.

It is neceſſary therefore that a varniſh ſhould be eaſily extended or ſpread over the ſurface, without leaving pores or cavities; that it ſhould not crack or ſcale; and that it ſhould reſiſt water. Now reſins are the only bodies that poſſeſs theſe properties.

Reſins conſequently muſt be uſed as the baſes of varniſh. The queſtion which of courſe preſents itſelf muſt then be, how to diſpoſe them for this uſe; and for this purpoſe they muſt be diſſolved, as minutely divided as poſſible, and combined in ſuch a manner that the imperfections of thoſe which might be diſpoſed to ſcale, may be corrected by others.

Reſins may be diſſolved by three agents— 1. By fixed oil. 2. By volatile oil. 3. By alcohol. And accordingly we have three kinds of varniſh: the fat or oily varniſh, eſſential varniſh, and ſpirit varniſh.

Before a reſin is diſſolved in a fixed oil, it is neceſſary to render the oil drying. For this purpoſe the oil is boiled with metallic oxides; in which operation the mucilage of the oil combines with the metal, while the oil itſelf unites with the oxigene of the oxide. To accelerate the drying of this varniſh, it is neceſſary to add oil of turpentine.

The eſſential varniſhes conſiſt of a ſolution of reſin in oil of turpentine. The varniſh being applied, the eſſential oil flies off, and leaves the reſin. This is uſed only for paintings.

When reſins are diſſolved in alcohol, the varniſh dries very ſpeedily, and is ſubject to crack; but this fault is corrected by adding a ſmall quantity of turpentine to the mixture, which renders it brighter, and leſs brittle when dry.

The coloured reſins or gums, ſuch as gum guttæ, dragon's blood, &c. are uſed to colour varniſhes.

To give luſtre to the varniſh after it is laid on, it is rubbed with pounded pumice ſtone and water; which being dried with a cloth, the work is afterwards rubbed with an oiled rag and tripoli. The ſurface is laſt of all cleaned with ſoft linen cloths, cleared of all greaſineſs with powder of ſtarch, and rubbed bright with the palm of the hand.

ARTICLE VI.

Concerning the Fecula of Vegetables.

The fecula appears to be only a ſlight alteration of mucilage; for it differs from that ſubſtance in no other reſpect than in being inſoluble in cold water, in which liquid it falls with wonderful quickneſs. If it be put into hot water, it forms a mucilage, and reſumes all its characters. It ſeems that the fecula is ſimply a mucilage deprived of caloric. In fact, a young plant is all mucilage; the old plants and fruits afford little fecula, becauſe the heat is ſtronger in young than in old plants, according to Dr. Hunter.

There are few plants which do not contain fecula. Mr. Parmentier has given us a liſt of all thoſe which afford it, in his experiments. (See his Recherches ſur les Vegetaux Nouriſſans.) But the ſeeds of gramineous and leguminous vegetables, as well as the roots, which botaniſts call Tuberoſe, contain it moſt plentifully.

Nothing more is required, in order to extract the fecula, than to bruiſe or grind the plant in water; and the fecula, which is at firſt ſuſpended in that fluid, ſoon falls to the bottom. We ſhall not in this place attend to any other feculæ but ſuch as are uſed in the arts or in medicine. Such are thoſe of bryony, of potatoes, caſſava, ſago, ſalep, ſtarch, &c.

1. The fecula of bryony is extracted from the root of that plant. The bark is firſt taken off from the root, which is then raſped, and ſubmitted to the preſs. The juice which flows out by expreſſion is rendered white and opake by a fecula which ſubſides. The liquid is then decanted off, and the fecula dried. It is ſtrongly purgative, on account of a portion of extract which it retains; but it may be deprived of its purgative virtue by careful waſhing in water. If water be poured on the marc which remains beneath the preſs, a large quantity is obtained which is not purgative, becauſe the extractive matter was forced out by the firſt operation. Mr. Baumé has propoſed to ſubſtitute this fecula inſtead of ſtarch. The fecula is afforded by ſimilar treatment of the roots of corn-flag and arum.

2. That which is generally known by the name of Potatoe Flour, is nothing but the fecula of this root obtained by ordinary and eaſy proceſſes. The root being well waſhed, it is pounded or cruſhed in ſuch a manner as perfectly to deſtroy its texture. The pulp is then

put into a ſieve, and water poured on it, which carries off the fecula, and depoſits it at the bottom of the receiving veſſel. The water, which is coloured by extractive matter, and part of the parenchyma that remains ſuſpended, is decanted off, and the depoſition is waſhed ſeveral times. The colour of the fecula grows whiter as it dries; and when dry it is very white and fine.

As this fecula has become an article of common uſe for ſome time paſt, ſeveral inſtruments have been contrived which are more or leſs ſuited to bruiſe the potatoes. Raſps have been propoſed turning in cylinders, mills armed with points of iron, &c.

3. The caſſava of the Americans is extracted from the roots of the manioc. This plant contains an acrid and very dangerous poiſon, of which it muſt be very carefully deprived. The Americans take the freſh root of manioc. which they peel, raſp, and incloſe in a bag or ſack formed of ruſhes, and of a very open texture. This bag is ſuſpended from a ſtaff; and a very heavy veſſel is faſtened to its lower part, which draws the bag down, ſo as in ſome meaſure to compreſs the root, at the ſame time that it receives the juice as it flows out. The juice is a moſt dreadful poiſon. When the root is

well cleared of the juice, it is put into the ſame bags, and expoſed to dry in the ſmoke. The ſifted root is called Caſſava. To convert it into food, it is ſpread out upon an hot brick or plate of iron; and when the ſurface which reſts immediately on the brick is of a reddiſh brown colour, it is turned, to bake the other ſide; and in this ſtate it forms what is called Caſſava Bread.

The expreſſed juice carries with it the fineſt part of the fecula, which quickly ſubſides; and this fecula, known by the name of Mouchaſſe, is uſed to make paſtry.

The poiſonous extract which moſt of theſe roots that abound in fecula contain, ought to engage thoſe who prepare them to be uncommonly attentive to the due management of the proceſs. Without the moſt ſcrupulous care the moſt unhappy conſequences may follow. It ſhould always be recollected, in the preparation of theſe ſubſtances, that the poiſon is in contact with the food.

A fecula has likewiſe been appropriated to domeſtic uſes, which is extracted from the pith of ſeveral farinaceous palms, and is known by the name of Sago. This preparation is made in the Molucca Iſlands. The pith of middle-aged palms is only uſed; for the young, as well as the old, afford very little fecula. This pith is mixed with water; and the fecula which is extracted, and renders the fluid white, is ſuffered to ſubſide. When the fecula is dried, it forms ſmall grains; which when reduced to powder, and mixed with warm water, afford a very nouriſhing pulp or mucilage.

M. Parmentier has propoſed to make ſago out of potatoes; in conſequence of his idea that all feculæ are abſolutely identical, and that this principle is one and the ſame in nature. For this purpoſe he propoſes to add a ſpoonful of the fecula of potatoes gradually to a chopin, or half a pint, of hot water or milk, to be kept ſtirring over a gentle fire for half an hour. Sugar may be added, with aromatics or ſpices, ſuch as cinnamon, lemon peel, ſaffron, orange-flower water, roſe-water, &c.

The ſago of potatoes may likewiſe be prepared with veal broth, chicken broth, or common broth. The preparation may be varied in a thouſand ways, and it forms a very wholeſome and nouriſhing food.

5. The bulbs of all the kinds of orchis may be uſed to make ſalep. All that is required to be done conſiſts in depriving them of the extractive principle, and drying the reſidue, which becomes tranſparent by this operation.

In order to dry them more ſpeedily, they are ſtrung, and hung up; or otherwiſe it is thought ſufficient to rub theſe bulbs in water either hot or cold, and to dry them in an oven. This laſt proceſs was communicated to Dr. Percival by Mr. John Moult.

The fecula of ſalep, pulverized, and combined with water, forms a very nouriſhing jelly.

6. The fecula is likewiſe one of the conſtituent principles of the ſeeds of gramineous plants; and when theſe have been ground, and reduced into farina, nothing more is required than to mix them with water, in order to precipitate the fecula. But another proceſs for procuring it is uſed in the arts: it conſiſts in deſtroying by fermentation the extractive and glutinous part with which it is intimately united; and in this conſiſts the art of making ſtarch. The proceſs of the ſtarch-maker conſiſts in fermenting grain, pollard, damaged flour, &c. in the acid water which they call *eau ſure*. When the fermentation is ended, they take out the fecula, which is precipitated to the bottom of the water, and put it into hair ſacks. Freſh water is poured upon this, which carries the finer fecula with it; and this being ſeveral times waſhed, conſtitutes ſtarch, cleared of every foreign principle.

There are likewiſe coloured feculæ, ſuch as indigo, which we ſhall treat of when we come to the article Dyeing.

The uſes of the feculæ are very numerous.

1. They conſtitute a very nouriſhing food, becauſe the nutritive virtue of gramineous vegetables reſides in them. Thoſe ſeeds which man has appropriated for his food, contain much; and theſe feculæ form a very nouriſhing jelly with hot water. It may be ſeen in the work of M. Parmentier, that this is truly the moſt ſuitable nouriſhment for man. Some of theſe are even entirely devoted to this purpoſe, ſuch as the caſſava.

In the northern climates, the lichens form almoſt the whole of the food of man, and ſuch animals as are not carnivorous; and theſe lichens, according to the experiments of the Academy of Stockholm, afford an excellent ſtarch by ſimple grinding. The rein-deer, the ſtags, and the other fallow cattle of the north of Europe, ſubſiſt on the lichen rangiferinus. The Icelanders obtain a very delicate gruel with the fecula of the lichen Icelandicus.

2. Starch boiled in water, and coloured with a ſmall quantity of azure, forms a paſte which is uſed to give brightneſs, firmneſs, ſtrength, and an agreeable colour, to linen.

3. The feculæ are alſo uſed to make hair powder; and this conſumption, which is prodigious, might be ſupplied by ſtarch made from

leſs valuable plants than the gramineous; and, if this were done, the objects of luxury would not enter into competiton with our moſt immediate wants.

ARTICLE VII.

Concerning the Vegetable Gluten.

The glutinous principle, which, on account of its properties reſembling thoſe of animal ſubſtances, has been called the Vegeto-Animal Subſtance by ſome chemiſts, is more particularly obtained from gramineous vegetables. We are indebted to Beccari for the diſcovery of this ſubſtance; and the analyſis of farinaceous ſubſtances has ſince been enriched with various important facts.

To make the analyſis of any farina, the methods employed are ſuch as are ſimple, and incapable of decompoſing or altering any of its conſtituent parts. A paſte is formed with the flour and water; and this is kneaded and wrought in the hands under water, till it no longer communicates any colour to that fluid. The ſubſtance which then remains in the hand is tenacious, ductile, and very elaſtic; and becomes more and more adheſive, in proportion as the water which it had imbibed flies off by evaporation. In this ſame operation the fecula falls to the bottom of the water; while the extractive matter remains in ſolution, and may be concentrated by evaporation of the fluid.

If the glutinous matter be ſtretched out, and then let go, it returns by ſpontaneous contraction to its original form. If it be left ſuſpended, it becomes extended by its weight; and forms a very thin tranſparent membrane, which exhibits a kind of net work, reſembling the texture of the membranes of animals.

M. Beccari has obſerved that the proportion of glutinous matter varies prodigiouſly in the ſeveral ſeeds of gramineous vegetables. Thoſe of wheat contain the largeſt quantity; but he never found it in the garden ſtuff or plants which are uſed by us as food. The quantity of glutinous matter alſo varies in the ſame kind of grain, according to the nature of the ſoil which has ſupported it. Humid ſituations afford ſcarcely any.

The glutinous matter emits a very characteriſtic animal ſmell. Its taſte is inſipid; it ſwells up upon hot coals; becomes ſoon and perfectly dry in a dry air, or by a gentle heat; in which ſtate it reſembles glue, and breaks ſhort like that ſubſtance. If in this ſtate it be placed on

burning

burning coals, it curls up, is agitated, and burns like an animal ſubſtance. By diſtillation it affords the carbonate of ammoniac.

Freſh-made gluten, expoſed to the air, readily putrefies; and when it has retained a ſmall quantity of ſtarch, this laſt paſſes to the acid fermentation, and retards the putrefaction of the gluten; and in this way a ſtate is produced reſembling that of cheeſe.

Water does not attack the glutinous part. If it be boiled with this fluid, it loſes its extenſibility and adheſive quality: a circumſtance ſo much the more remarkable, as it was indebted to that fluid for the development of theſe qualities; for this principle exiſted without coheſion in the flour; and when it is deprived of water by drying, it alſo loſes its elaſticity and glutinous quality.

Alkalis diſſolve it, by the aſſiſtance of a boiling heat. The ſolution is turbid; and depoſits the gluten by the addition of acids, but deprived of its elaſticity.

The nitric acid diſſolves gluten with activity: and this acid at firſt emits the nitrogenous gas, as when treated with animal ſubſtances. This is followed by an emiſſion of nitrous gas; and the reſidue, by evaporation, affords the oxalic acid in cryſtals.

The ſulphuric and muriatic acids likewiſe diſſolve it. M. Poulletier has obſerved, that ſalts with baſe of ammoniac may be obtained from theſe combinations, diſſolved in water or alcohol, and evaporated in the open air.

If the gluten be diſſolved in the vegetable acids ſeveral times repeatedly, and precipitated by alkalis, it is reſtored to the ſtate of fecula: and, according to Macquer, if vinegar be diſtilled by a gentle heat from this ſubſtance, it is reduced to the ſtate of mucilage.

This ſubſtance therefore poſſeſſes a very decided animal character. It is to this gluten that wheat owes its property of making a good paſte with water, and the facility with which it riſes. Rouelle diſcovered a glutinous ſubſtance analogous to the preſent in the green fecula of plants, which afford ammoniac, and empyreumatic oil, by diſtillation. The expreſſed juice of the herbaceous plants likewiſe afforded it; ſuch as that of borage, hemloc, ſorrel, &c.

The gluten is ſometimes deſtroyed by the fermentation of flour; by which change it is deprived of the wholeſome qualities it before poſſeſſed, and is incapable of riſing, and forming good bread.

Farina, or flour, is therefore compoſed of three principles—the amylaceous principle, or ſtarch; the ſaccharine principle; and the animal or glutinous principle. Whenever therefore, by a ſuitable diviſion, theſe principles are mixed together, and the fermentation is aſſiſted by the known methods, each of theſe principles being capable of a different kind of fermentation, becomes decompoſed in its own peculiar manner. The ſaccharine principle undergoes the ſpirituous fermentation; the glutinous ſuffers the proceſs of animal putrefaction; and the amylaceous is changed by the acid fermentation. The panary fermentation may therefore be conſidered as an union of theſe three different ſpontaneous changes. But as ſoon as the leading phenomena of the fermentation are well developed; and the principles, already well mixed and aſſimilated, have by this means ſuffered a change in their reſpective natures; the fermentation is ſtopped by baking; and the bread is found to be much lighter in conſequence of theſe preliminary operations.

The art of making bread was not known at Rome until the year 585. The Roman armies, on their return from Macedonia, brought Grecian bakers into Italy. Before this time the Romans prepared their flour in no other way than by making it into pap or ſoft pudding;

for which reaſon the Romans, according to Pliny, were called Eaters of Pap.* See Aubry.

ARTICLE VIII.

Concerning Sugar.

Sugar is likewiſe a conſtituent part of vegetables, exiſting in conſiderable quantities in a number of plants. It is afforded by the maple, the birch, wheat, and Turkey corn. Margraaf obtained it from the roots of beet, red beet, ſkirret, parſneps, and dried grapes. The proceſs of this chemiſt conſiſted in digeſting theſe roots, raſped or finely divided, in alcohol. This fluid diſſolves the ſugar, and leaves the extractive matter untouched, which falls to the bottom.

In Canada the inhabitants extract ſugar from the maple (acer montanum candidum). At the commencement of the ſpring they heap ſnow in the evening at the foot of the tree, in which they previouſly make apertures for the paſſage of the returning ſap. Two hundred pounds of this juice afforded by evaporation fifteen of a browniſh ſugar. The quantity prepared annually amounts to fifteen thouſand weight.

---

* Pulte autem, non pane, vixiſſe longo tempore Romanos manifeſtum, quoniam inde et Pulmentaria hodieque dicuntur. Plin. Hiſt. Nat. lib. xviii. cap. viii. et xi.—The date is 580 ab urbe conditâ. T.

The Indians likewiſe extract ſugar from the pith of the bamboo.

But the ſugar which is ſo univerſally uſed is afforded by the ſugar cane (arundo ſaccharifera) which is raiſed in our colonies. When this plant is ripe, it is cut down, and cruſhed by paſſing it between iron cylinders, placed perpendicularly, and moved by water or animal ſtrength. The juice which flows out by this ſtrong preſſure is received in a ſhallow trough placed beneath the cylinder. This juice is called *veſou*; and the cane, after having undergone this preſſure, is called *begaſſe*.* The juice is more or leſs ſaccharine, according to the nature of the ſoil on which the cane has grown, and the weather that has predominated during its growth. It is aqueous when the ſoil or the weather has been humid; and in contrary circumſtances it is thick and glutinous.

The juice of the cane is conveyed into boilers, where it is boiled with wood aſhes and lime:

---

* Theſe are the names in the French ſugar colonies. I do not find the correſponding terms in any of our writers. T.

It is ſubjected to the ſame operation in three ſeveral boilers, care being taken to remove the ſkum as it riſes. In this ſtate it is called Syrup; and is again boiled with lime and alum till it is ſufficiently concentrated; when it is poured into a veſſel called the Cooler. In this veſſel it is agitated with wooden ſtirrers, which break the cruſt as it forms on the ſurface. It is afterwards poured into caſks, to accelerate its cooling; and, while it is ſtill warm, it is conveyed into barrels ſtanding upright over a ciſtern, and pierced through their bottom with ſeveral holes ſtopped with cane. The ſyrup which is not condenſed filters through theſe canes into the ciſtern beneath; and leaves the ſugar in the ſtate called Coarſe Sugar, or Muſcovado. This ſugar is yellow and fat, and is purified in the iſlands in the following manner:—The ſyrup is boiled, and poured into conical earthen veſſels, having a ſmall perforation at the apex, which is kept cloſed. Each cone, reverſed on its apex, is ſupported in another earthen veſſel. The ſyrup is ſtirred together, and then left to cryſtallize. At the end of fifteen or ſixteen hours, the hole in the point of each cone is opened, that the impure ſyrup may run out. The baſe of theſe ſugar loaves is then taken out, and white pulverized ſugar ſubſtituted in its ſtead; which being well preſſed down, the whole is covered with clay, moiſtened with water. This water filters through the maſs, carrying the ſyrup with it which was mixed with the ſugar, but which by this management flows into a pot ſubſtituted in the place of the firſt. This ſecond fluid is called Fine Syrup. Care is taken to moiſten and keep the clay to a proper degree of ſoftneſs, as it becomes dry. The ſugar loaves are afterwards taken out and dried in a ſtove for eight or or ten days; after which they are pulverized, packed, and exported to Europe, where they are ſtill farther purified.

The operation of our ſugar refiners conſiſts in diſſolving the caſſonade, or clayed ſugar, in lime water. Bullocks blood is added, to promote the clarifying; and, when the liquor begins to boil, the heat is diminiſhed, and the ſkum carefully taken off. It is in the next place concentrated by a briſk heat; and, as it boils up, a ſmall quantity of butter is thrown in, to moderate its agitation. When the boiling is ſufficiently effected, the fire is put out; the liquor is poured into moulds, and agitated, to mix the ſyrup together with the grain ſugar already formed. When the whole is cold, the moulds are opened, the loaves are covered with moiſtened clay, which is renewed from time to time till the ſugar is well cleared from its ſyrup. The loaves being then taken out of the moulds, are carried to a ſtove, where they are gradually heated to the fiftieth degree of Reaumur. They remain in this ſtove eight days, after which they are wrapped in blue paper for ſale.

The ſeveral ſyrups, treated by the ſame methods, afford ſugars of inferior qualities; and the laſt portion, which no longer affords any cryſtals, is ſold by the name of Melaſſes. The Spaniards uſe this melaſſes in the preparation of ſweetmeats.

A ſolution of ſugar, much leſs concentrated than that we have juſt been ſpeaking of, lets fall by repoſe cryſtals which affect the form of tetrahedral priſms, terminated by dihedral ſummits, and known by the name of Sugar Candy.

Sugar is very ſoluble in water; it ſwells up in the fire, becomes black, and emits a peculiar ſmell, known by the denomination of the ſmell of caromel.

Sugar is very much uſed for domeſtic purpoſes. It conſtitutes the baſis of ſyrups; and is uſed at our tables to diſguiſe the ſour taſte of fruit and vegetable juices. It corrects the bitterneſs of coffee; and ſerves as the vehicle in a great number of pharmaceutical preparations.

Sugar is an excellent food; and it is merely an old prejudice to ſuppoſe it produces worms in the bowels of children.

It is now ſeveral years ſince the celebrated Bergmann taught us to extract a peculiar acid from ſugar, by combining the oxigene of the nitric acid with one of its conſtituent principles. The diſcovery of the acid of ſugar was conſigned in a theſis maintained at Upſal, the 13th of June 1776, by M. Arvidſon, under the preſidency of Bergmann.

To make the acid of ſugar, or oxalic acid, nine parts of the nitric acid, with one of ſugar, are put into a retort. A gentle heat is applied, to aſſiſt the action of the acid; which is rapidly decompoſed upon the ſugar, with the diſengagement of a conſiderable quantity of nitrous gas. When the decompoſition is completed, the diſtillation is continued on a ſand bath, till the reſidue is ſufficiently concentrated. It is then ſuffered to cool; and beautiful cryſtals are formed, which may be taken out, and have the figure of a tetrahedral priſm terminating in a dihedral ſummit. By a farther concentration of the liquor in which the acid has cryſtallized, more of theſe cryſtals may be obtained. Theſe ſeveral products of cryſtals are then to be diſſolved in pure water, and again cryſtallized, to ſeparate them from any admixture of nitric acid

that

that may adhere to them. This acid was formerly thought to be a modification of the nitric acid; and Bergmann was under the neceſſity of entering into a conſiderable detail of reaſoning, to remove every doubt on the ſubject. But the knowledge we at preſent poſſeſs reſpecting the conſtituent principles of the nitric acid, and the great number of phenomena of this kind which it exhibits when made to act on various ſubſtances, render it unneceſſary for us to enter into this conſideration.

Cold water diſſolves half its weight of this acid, and boiling water takes up its own weight.

This acid, combined with pot-aſh, forms a ſalt in priſmatic hexahedral flattened rhomboidal cryſtals, terminating in dihedral ſummits. In order that cryſtallization may take place, it is neceſſary that one of the component parts ſhould be in exceſs. This ſalt is very ſoluble in water.

The ſame acid forms with ſoda a ſalt which is very difficult to be brought to cryſtallize, and which converts ſyrup of violets to a green.

This acid, poured upon ammoniac, affords by a ſlight evaporation very beautiful tetrahedral priſmatic cryſtals, terminating in dihedral ſummits; one of whoſe faces is larger than the other, ſo that it occupies three angles of the extremity. See my Memoirs of Chemiſtry.—This ſalt is of great uſe in the analyſis of mineral waters. It inſtantly ſhews the preſence of any ſalt with baſis of lime, becauſe the oxalate of lime is inſoluble in water.

The acid of ſugar, or oxalic acid, attacks and diſſolves moſt of the metals: but its action upon the oxides is ſtronger than upon the metals themſelves; and it takes the oxides from their true ſolvents. In this way it is that it precipitates iron from a ſolution of the ſulphate of iron, in a ſubſtance of the moſt beautiful yellow colour, which may be uſed in painting.

It precipitates copper in the form of a white powder, which becomes of a beautiful light green by drying.

Zinc is precipitated of a white colour.

This acid likewiſe precipitates mercury and ſilver, but not till after ſeveral hours ſtanding.

An account of the combinations of this acid with various baſes may be ſeen in Bergmann's treatiſe.

This acid may be extracted, by the action of nitric acid, from a number of vegetable ſubſtances, ſuch as gums, honey, ſtarch, gluten, or alcohol; and from ſeveral animal ſubſtances, according to the diſcovery of M. Berthollet, ſuch as ſilk, wool, and lymph.

M. de Morveau, who has made a very valuable ſeries of experiments on the acid of ſugar, has proved that the whole of the ſugar does not enter into the formation of the acid, but only one of its principles; and he affirms that it is an attenuated oil which exiſts in a variety of ſubſtances.

Since it has been aſcertained, from the experiments of Scheele, Weſtrumb, Hermſtadt, and others, that the acid of the ſalt of ſorrel does not at all differ from that of ſugar, they have been accordingly confounded under the ſame denomination; and that ſalt which is known in commerce by the name of Salt of Sorrel, is an acidulous oxalate of potaſh.

The ſalt of ſorrel is made in Switzerland, in the Hartz, in the foreſts of Thuringia, in Swabia, and elſewhere. It is extracted from the juice of the ſorrel called Alleluya. Juncker, Boerhaave, Margraaff, and others, have deſcribed the proceſs uſed for its extraction. The juice of ſorrel is expreſſed, diluted with water, filtered, and evaporated to the conſiſtence of cream. It is then covered with oil, to prevent its fermentation, and left in a cellar for ſix months.

According to Mr. Savary, fifty pounds of this plant afford five and twenty of juice, from which no more than two ounces and a half of the ſalt are obtained. Six parts of boiling water diſſolve one of the ſalt. It appears to cryſtallize in parallelopipedons, according to De Liſle.

Margraaff obſerved that the nitric acid, digeſted upon ſalt of ſorrel, afforded nitre.

Calcareous earth has the property of diſengaging the alkali; and in this operation the carbonic acid of the chalk unites with the alkali of the ſalt, and forms a carbonate of potaſh.

Salt of ſorrel unites with other baſes without yielding its own, ſo that the reſults are triple ſalts. See the Encyclopedie Methodique, tom. i. p. 200, 201.

The pure oxalic acid may be obtained by diſtillation of this ſalt, as Mr. Savary informs us; or otherwiſe by depriving it of its alkali by means of ſulphuric acid, and diſtillation, according to Wiegleb's method; or otherwiſe by the proceſs of Scheele, which conſiſts in ſaturating the exceſs of acid with ammoniac, and pouring the nitrate of barytes into the ſolution. The nitric acid then ſeizes the two alkalis, while the oxalic acid unites with the barytes, and falls down. The barytes is afterwards taken from its combination by the ſulphuric acid, and leaves the oxalic acid diſengaged.

Scheele has likewiſe propoſed another method of obtaining the pure oxalic acid. It conſiſts in diſſolving the ſalt in water, and pouring in a ſolution of ſalt of ſaturn. A precipitate is formed; and the ſupernatant liquor contains the alkali of the ſalt of ſorrel, united with a portion of the vinegar. The precipitate is then waſhed, and ſulphuric acid poured on, which unites with the lead: and, by filtering and evaporating, the oxalic acid is obtained in cryſtals, ſimilar to thoſe of the acid of ſugar.

Scheele has proved the identity of the acid of ſalt of ſorrel with that which is extracted from ſugar. He diſſolved the acid of ſugar to ſaturation in cold water, and into this he very gradually poured a well-ſaturated ſolution of potaſh. During the effervеſcence, he obſerved that ſmall tranſparent cryſtals were formed, which were found to be a true ſalt of ſorrel.

Mr. Hoffman has proved that the juice and the cryſtals of the berberris vulgaris contain the oxalic acid combined with potaſh. And the celebrated Scheele has proved that the earth of rhubarb is a combination of the oxalic acid with lime.

ARTICLE IX.

Concerning the Vegetable Acids.

The vegetable acids have been long conſidered to be weaker than the others; and this opinion was adhered to until it was obſerved that the oxalic acid ſeized lime from the ſulphuric acid. The principal character which may ſerve to eſtabliſh a line of diſtinction between the vegetable acids and others are—1. Their volatility; for there are none which do not riſe with a moderate heat. 2. Their property of leaving a coaly reſidue after combuſtion, and of emitting an empyreumatic ſmell in burning. 3. The nature of their acidifiable baſe, which is in general oily.

But are all the vegetable acids identical in their nature? And may they not be conſidered as modifications of one and the ſame acid?

If we depend on the principle laid down by the celebrated Monro, who conſiders no acids as identical but ſuch as form exactly the ſame ſalts with the ſame baſe (Phil. Tranſ. vol. lvii. p. 479), there will be no queſtion but that all the known acids ought to be conſidered as very different from each other. But this method of proceeding appears to me to be erroneous; becauſe in this caſe the various degrees of ſaturation of the ſame principle with oxigene, would eſtabliſh various kinds of acids. The ſlow or the rapid combuſtion of phoſphorus cauſes ſufficient modifications in the acid to afford different phoſphoric ſalts, according to the Experiments of Meſſ. Sage and Lavoiſier. But ought we on this account to admit of two ſpecies of phoſphoric acid? By following the method of Monro, which is that of moſt chemiſts, we might multiply the vegetable acids to infinity; but by collating the experiments of Hermſtadt, Crell, Scheele, Weſtrumb, Berthollet, Lavoiſier, &c. we may obſerve that the vegetable acids are merely modifications of one or two primitive acids.

1. Scheele obtained vinegar by treating ſugar and gum with manganeſe and the nitric acid. He obſerved that tartar had the ſame effect or habitude as ſugar in the ſolution of manganeſe by the nitric acids; and that vinegar was found after the decompoſition of ether.

Mr. Crell, by boiling the reſidue of nitric alcohol (dulcified ſpirit of nitre) with much nitric acid, taking care to adapt veſſels to condenſe the vapour, and ſaturating what came over with alkali, obtained nitrate and the acetate of potaſh. The latter being ſeparated by alcohol, gives out its vinegar by the uſual treatment.

3. The ſame chemiſt, by boiling the pure oxalic acid with twelve or fourteen parts of nitric acid, obſerved that the former diſappears; and the receiver is found to contain nitrous acid, acetous acid, carbonic acid, and nitrogenous gas; and in the retort there remains a little calcareous earth*.

4. By ſaturating the reſidue of nitric alcohol with chalk, an inſoluble ſalt is obtained; which, treated with the ſulphuric acid, affords a true tartareous acid.

5. By boiling one part of oxalic acid with one part and a half of manganeſe, and a ſufficient quantity of nitric acid, the manganeſe is almoſt totally diſſolved, and vinegar with nitrous acid paſs into the receiver.

6. By boiling tartareous acid and manganeſe with the ſulphuric acid, the manganeſe is diſſolved, and vinegar with ſulphuric acid are obtained.

7. By digeſting for ſeveral months the tartareous acid and alcohol, the whole becomes

---

* There being an obvious overſight in the author's paragraph, I have taken the liberty to reſtore the paſſage from Crell's original. Journal de Phyſ. Oct. 1785, quoted by Dr. Beddoes at the end of the Engliſh Tranſlation of Scheele's Eſſays. London, 1789. T.

changed into vinegar; and the air of the veſſels is found to conſiſt of carbonic acid and nitrogene gas.

From theſe facts Crell concludes that the tartareous, oxalic, and acetous acids, are merely modifications of the ſame acid.

In the Journal de Phyſique for September 1787, is inſerted a memoir of M. Hermſtadt on the converſion of the oxalic and tartareous acids into acetous acid.

1. By cauſing the oxigenated muriatic acid to paſs through very pure alcohol, ether is produced; and the oxigenated acid reſumes its character of ordinary muriatic acid. The ether by diſtillation affords—1. Ether. 2. Muriatic alcohol. 3. Vinegar mixed with regenerated muriatic acid.

2. Nitric acid diſtilled, for ſeveral ſucceſſive times, from the oxalic and tartareous acids, converts them totally into acetous acid.

3. Two parts of oxalic acid, three of ſulphuric acid, and four of mangameſe, mixed with one part and a half of water, and diſtilled together, afford acetous acid, which requires to be recohobated and rediſtilled to become very pure.

4. If the ſulphuric acid be boiled upon the oxalic or the tartareous acid, theſe two laſt are not deſtroyed, as Bergmann thought, but they

are converted into acetous acid. It is proved, by the experiments of M. Hermſtadt, that the ſulphureous acid in the receiver, when ether is made, is mixed with much acetous acid.

It appears therefore to be proved that the tartareous, oxalic, and acetous acids differ from each other only in the proportion of oxigene.— In the above experiments the mineral acids are always decompoſed; and, by ſaturating the radical with their oxigene, they conſtantly form the acetous acid. If the ſaturation be not exact, the reſult is either oxalic or tartareous acid; which is ſtill more proved by a fine experiment of M. Hermſtadt. If three parts of fuming nitric acid be put into the pneumatic apparatus, and a large jar be adapted, filled with water; if then one part of good alcohol be poured in, by a little at a time, the mixture will be heated every time a drop of the alcohol is let fall, and a great quantity of bubbles will riſe into the receiver. When the operation is ended, if care be taken to collect the gas, it will be found to conſiſt of nitrous gas, a ſmall quantity of carbonic acid, and about a twelfth part of the acetous air of Prieſtley. The reſidue affords oxalic acid and acetous acid. The oxalic acid diſappears if the operation be continued; ether is formed;

and the acetous acid remains, and becomes more in quantity.

M. Hermſtadt has likewiſe ſucceeded in converting the acids of tamarinds, of citrons, of marc of grapes, the juice of plums, apples, pears, gooſeberries, berberries, ſorrel, and others, into the oxalic, tartareous, and acetous acids.

From all theſe experiments it appears, that the oxigene, combined with a principle of alcohol, forms the oxalic acid; and that a more accurate ſaturation of this principle with oxigene forms the tartareous and acetous acids.

M. Lavoiſier has proved that the known vegetable acids do not differ from each other but in the proportion of hydrogene and carbone, and in their degree of oxigenation.

I have proved (in the Memoirs of the Academy of Sciences of Paris for the year 1786) that water impregnated with the gas diſengaged from the juice of grapes in fermentation, paſſes to the ſtate of acetous acid.

It appears that the vegetable acids may be conſidered in two very different points of view. Moſt of them exiſt in the plant itſelf; but the properties and acid characters are diſguiſed by their combination with other principles, ſuch as oils, earths, alkalis, &c. On the other hand, ſeveral acids are extracted from vegetables, which did not exiſt in nature. In this caſe the plant contained only the radical, and the reagent with which it is treated affords the oxigene.

The mere diſtillation of moſt vegetables is ſufficient to develop an acid, which was diſguiſed by oily, alkaline, or earthy ſubſtances.

1. The peculiar acid called the Pyro-mucilaginous acid, is afforded by diſtillation by all plants which contain a ſaccharine juice.

For the preparation of this acid, the quantity of ſugar intended to be operated upon is put into a very capacious retort (the large ſize being requiſite, becauſe the matter ſwells up), and a receiver ſufficiently ample to condenſe the vapour is adapted. An aſtoniſhing quantity of carbonic acid and hydrogene gas are diſengaged by the firſt impreſſion of the fire. A brown fluid remains in the receiver, moſt of which conſiſts of a weak acid, colouring blue paper, and rendered dark by a portion of oil. The retort contains a ſpongy coal. M. Schrickel adviſes the rectification of the product of the firſt diſtillation from clay, in order to purify the acid: but M. de Morveau has rediſtilled it without intermedium; and the acid he obtained had only a ſlight yellow tinge. Its ſpecific gravity was 1,0115, the thermometer ſtanding at twenty degrees.

As this acid riſes at the ſame temperature as water, it is not poſſible to concentrate it by diſtillation. But this purpoſe may be effected by freezing; and in this manner it was that M. Schrickel prepared the acid he made uſe of to aſcertain its combinations.

This acid exiſts in all bodies capable of paſſing to the ſpirituous fermentation, while they contain only the radical of the oxalic acid. The pyromucilaginous acid is combined in the vegetable with oils in the ſaponaceous ſtate.

This concentrated acid has a very penetrating taſte. It ſtrongly reddens blue colours. If it be expoſed to heat in open veſſels, it is diſſipated, and leaves only a brown ſpot. If it be heated in cloſed veſſels, it leaves a more conſiderable reſidue, of the nature of the coal of ſugar.

This acid ſpeedily attacks the earthy and alkaline carbonates, and forms ſalts differing from the oxalates. According to M. Schrickel, it diſſolves gold. He affirms that he made the experiment in the preſence of Fred. Aug. Cartheuſer. Lemery had aſſerted that the ſpirit of honey poſſeſſed this property; and this opinion is likewiſe ſupported in the works of Depré, Etmuller, &c. Neumann oppoſed the aſſertion; and the experiments of M. de Morveau confirm thoſe of this laſt chemiſt.

Silver is not attacked by the pyromucilaginous acid: but mercury combines with it by virtue of a long digeſtion. Conſult De Morveau.

This acid corrodes lead, and forms a very ſtyptic ſalt in long cryſtals. With copper it forms a green ſolution. It partly diſſolves tin, and affords green cryſtals with iron.

2. The denomination of the Pyroligneous Acid has been given to the acid obtained by diſtillation from wood. It has been long known that the hardeſt woods afford an acid principle, mixed with an oil, which partly diſguiſes its properties; but no one had directly attended to a determination of the habitudes of this acid, till M. Goettling publiſhed, in Crell's Annals for 1779, a ſeries of reſearches on the acid of wood, and the ether it affords.

M. de Morveau, to obtain this acid, diſtilled ſmall pieces of very dry beech in an iron retort, by a reverberatory furnace. He changes the receiver when the oil begins to riſe, and rectifies his product by a ſecond diſtillation. Fifty-five ounces of very dry chips afforded ſeventeen ounces of rectified acid, of an amber colour, not at all empyreumatic; whoſe ſpecific gravity, compared with that of diſtilled water, was as 49 : 48.

This acid ſtrongly reddens blue vegetable colours. One ounce required twenty-three ounces and a half of lime-water for its complete ſaturation.

It ſupports the action of heat very well when it is engaged in an alkaline baſe; but by a ſtrong heat it is burned, like all the vegetable acids.

It does not precipitate martial ſolutions of a black colour.

It unites with alkalis, earths, and metals. It does not give up lime or barytes to combine with cauſtic alkalis.

The action of the pyroligneous acid upon metallic ſubſtances, and upon alumine, may be compared with that of the acetous acid, and appears to follow the ſame order.

This acid diſſolves near twice its weight of the oxide of lead.

3. The citric acid. Lemon juice is in a diſengaged ſtate in the fruit, and exhibits its acid properties without any preparation. This acid is nevertheleſs always mixed with a mucilaginous principle, capable of altering by fermentation. Mr. Georgius has deſcribed, in the Memoirs of Stockholm for the year 1774, a method of purifying this acid without changing its properties. He fills a bottle with lemon juice, cloſes it with a cork, and preſerves it in a cellar.

lar. The acid was preſerved for four years, without corrupting. The mucilaginous parts had fallen down in flocks; and a ſolid cruſt was formed beneath the cork, the acid itſelf having become as limpid as water. To dephlegmate the acid, he expoſes it to froſt; and obſerves that the temperature ought not to be too cold, becauſe in that caſe the whole would become ſolid; and though the acid would thaw the firſt, it would always be productive of ſome inconvenience. In order to concentrate it to better advantage, the ice muſt be ſeparated as it forms. The firſt ice is taſteleſs, and the laſt is rather four; and by this means the liquor is reduced to half. The acid thus concentrated is eight times as ſtrong, two gros only being required to ſaturate one gros of potaſh.

The citric acid, when thus purified and concentrated, may be kept for ſeveral years in a bottle; and ſerves for all uſes, not excepting that of making lemonade.

The chemiſts in general, who have examined the combinations of the citric acid, have uſed it in its original ſtate, embarraſſed with its mucilaginous principle. Such is the reſult of the experiments of M. Wenzel, who obtained only gummy products. But M. de Morveau having ſaturated the purified acid with cryſtals of potaſh, found a non-deliqueſcent ſalt at the end of a certain time.

The combinations of this acid are little known.

4. The malic acid.—This acid was announced by Scheele in 1785, and publiſhed in Crell's Annals. In order to obtain it, the juice of apples is ſaturated with alkali, and the acetous ſolution of lead is poured in until it occaſions no more precipitate. The precipitate is then edulcorated, and ſulphuric acid poured on it until the liquor has acquired a freſh acid taſte, without any mixture of ſweetneſs. The whole is then filtered, to ſeparate the ſulphate of lead. This acid is very pure, always in the fluid ſtate, and cannot be rendered concrete.

It unites with the three alkalis, and forms deliqueſcent neutral ſalts. When ſaturated with lime, it affords ſmall irregular cryſtals, which are ſoluble only in boiling water. Its habitude with barytes is the ſame as with lime.

With alumine it forms a neutral ſalt of ſparing ſolubility in water, and with magneſia a deliqueſcent ſalt.

It differs from the citric acid—1. Becauſe the citric acid ſaturated with lime and precipitated by the ſulphuric acid, cryſtallizes: whereas this is not cryſtallizable. 2. The malic acid, treated with the nitric acid, affords the oxalic acid; the citric acid does not afford it. 3. The citrate of lime is almoſt inſoluble in boiling water: the malate of lime is more ſoluble. 4. The malic acid precipitates the ſolutions of the nitrates of lead, of mercury, and of ſilver; but the citric acid produces no change. 5. If the ſolutions of the nitrate of ammoniac, and malate of lime, be boiled together for an inſtant, the latter ſalt is decompoſed, and nitrate of lime falls down; which proves that the affinity of the malic acid with lime is weaker than that of the nitric.

The celebrated Scheele, who has rendered us acquainted with this acid, has publiſhed the following table of the fruits which afford this acid, either pure or mixed with other acids.

The expreſſed juices of the fruits of

Berberris vulgaris, the Barberry tree,	Afford much malic acid, and little or none of the citric acid.
Sambucus nigra, Elder,	
Prunus ſpinoſa, Sloe,	
Sorbus aucup. Service,	
Prunus domeſtic. Garden plum,	
Ribes groſſularia, the Hairy Gooſeberry,	Appear to contain half of the one and half of the other.
Ribes rubrum, the Currant,	
Vaccinium mirtellus, Whortleberry,	
Cratægus aria, Common Lotus,	
Prunus Ceraſus, Cherry,	
Fragaria veſca, Strawberry,	
Rubus chamemorus, Bilberry,	
Rubus idæus, Raſpberry,	

Vaccinium oxycacos, Marſhwhortle,	Contain much citric, and little or none of the malic acid.
Vaccinium Vitis Idæa,	
Prunus padus, Bird's Cherry,	
Solanum dulcamara,	
Cynoſbatos, Eglantine,	
Citrus, Citron or Lemon,	

According to the ſame chemiſt, the juice of green grapes, as well as that of tamarinds, contains only the acid of citrons.

Scheele has likewiſe proved the exiſtence of the malic acid in ſugar. If weak nitric acid be poured on ſugar, and diſtilled till the mixture begins to turn brown, all the oxalic acid may be precipitated by the addition of lime-water; and another acid will remain, which the lime-water does not precipitate. To obtain this acid in a ſtate of purity, the liquor is ſaturated by means of chalk, then filtered, and alcohol added, which occaſions a coagulation. This coagulation, well waſhed in alcohol, is re-diſſolved in diſtilled water. The malate of lime is decompoſed by the acetate of lead; and, laſt of all, the malic acid is diſengaged by the ſulphuric acid. The alcohol by evaporation leaves a ſubſtance rather bitter than ſweet, which is deliqueſcent, and reſembles the ſaponaceous matter of lemon juice. If a ſmall quantity of nitric acid be diſtilled from this, the malic and oxalic acids are obtained.

By treating various other ſubſtances with the nitric acid, the malic and the oxalic acids are likewiſe obtained. Such are gum arabic, manna, ſugar of milk, gum adragant, ſtarch, and the fecula of potatoes. The extract of nutgalls, the oil of parſley-ſeed, the aqueous extract of aloes, of coloquintida, of rhubarb, of opium, afforded not only the two acids to Mr. Scheele, but likewiſe much reſin.

This celebrated chemiſt, by treating ſeveral animal ſubſtances with very concentrated nitric acid, obtained the malic and the oxalic acids from them. Fiſh glue, or iſinglas, white of egg, yolk of egg, and blood, treated in the ſame manner, afforded the ſame products.

There are few vegetables which do not exhibit ſome acid more or leſs developed. We ſee, for example, all fruits, inſipid at firſt, become inſenſibly acid; and finiſh by loſing that taſte, and become ſaccharine. There are ſome which conſtantly preſerve an acid taſte, and form a particular claſs.

Some plants contain an acid principle diffuſed through the whole parenchyma or body of the vegetable. Such are the yellow gillyflower, bardana or waterdock, filipendula or dropwort, water creſſes, the herb robert, &c. Theſe plants ſenſibly redden blue paper.

There are others in which the acid principle exiſts only in part of the plant; as, for example, in the leaves of the greater valerian, the fruit of the winter cherry and of the cornel tree, the bark of burdock, and the root of ariſtolochia or birthwort.

Mr. Monro communicated ſome experiments to the Royal Society of London, in 1767, which prove that certain vegetables contain acids nearly in a diſengaged ſtate, and even ſuch as are the leaſt promiſing on a ſlight examination.

1. Having peeled two dozen of ſummer apples, and cut them into ſmall pieces, he poured water upon them, in which he had previouſly diſſolved two ounces of ſoda, and left the whole to ſtand for ſix days. The filtrated liquor, evaporated, and left in repoſe for ſix days more, afforded a beautiful ſalt, in ſmall round tranſparent plates, placed edgewiſe on each other.

2. The juice of mulberries clarified with the white of egg, and ſaturated with ſoda, afforded a pulverulent ſalt of no regular figure; which by repeated ſolutions and evaporations, at laſt produced long cryſtals, one kind being thin, and the other thicker, which croſſed each other.

3. He obtained ſmall cubical or rhomboidal cryſtals by treating peaches and oranges with ſoda.

4. The green plum afforded, after ſeveral

ſolutions and cryſtallizations, a neutral ſalt, which cryſtallized without evaporation in large hexagonal plates, and partly in large rhombi. This ſalt had a hot taſte, and was ſoluble in three or four times its weight of cold water.

5. The red gooſeberry afforded, by evaporation and cooling, ſmall very hard rhomboidal cryſtals, not changeable in the air; whoſe taſte reſembled that of the ſalt produced by a combination of the citric acid with the ſame baſe.

The green gooſeberry produced a ſaline cruſt formed of ſmall rhomboidal cryſtals, and covered with their brilliant ſcales.

6. The green grape afforded Mr. Monro, by repeated ſolutions, a neutral ſalt, in ſmall cubical cryſtals, of a rhomboidal or parallelogramic figure, lying upon and interſecting each other.

The juice of hemloc afforded M. Baumé a ſalt in ſmall irregular cryſtals, nearly taſteleſs, but reddening the infuſion of turnſole.

7. M. Rinman, in his Hiſtory of Iron, places the ſorb-apple and ſloe among the ſubſtances capable of corroding and cleanſing the ſurface of this metal, on account of their acid.

When, by the decompoſition of certain vegetables by the nitric acid, an acid was obtained as the laſt reſult, it was thought to have exiſted ready formed in the vegetable; but a more intimate examination ſhewed that the acid made uſe of in this operation was merely decompoſed, while it deſtroyed the organization of the vegetable, diſunited the combinations which retained the principles, and that the oxigenous baſe of this acid, by uniting with an element of the vegetable, formed a peculiar acid. This truth is deduced from the combined proceſſes of M. Lavoiſier, De Morveau, &c.

It is to a ſimilar cauſe that we ought to attribute the formation of the acetous, the carbonic, and other vegetable acids; and even the rancidity of oils, and the alteration to which ſome other principles of the vegetable kingdom are ſubject. In theſe caſes the air affords the oxigene which becomes fixed in the plant, and gives it an acid nature.

The oxalic acid does not exiſt ready formed in ſugar, neither is the camphoric acid ready formed in camphor. The ſame may be obſerved of ſeveral other acids which are extracted by means of certain acids decompoſed by being treated with vegetable ſubſtances. We ſhall ſpeak of theſe acids when we come to treat of their radical principles.

ARTICLE X.

Concerning Alkalis.

Alkali exiſts ready formed in plants. Duhamel and Groſſe have proved that it might be extracted by means of acids. Margraaf and Rouelle have added new proofs in ſupport of the aſſertions of thoſe chemiſts. They have obſerved, from their experiments, that the alkali exiſted in a diſengaged ſtate in vegetables: but theſe experiments proved at moſt that their ſtate of combination is ſuch that it may be broken by the mineral acids. The alkali, in ſome inſtances, is nearly in a diſengaged ſtate; for it is found in combination with carbonic acid in the helianthus annuus. But the alkali of plants is often combined with the oily principle.

When it is required to extract the alkali from a vegetable ſubſtance, all the principles with which it may be united, are deſtroyed by fire; and it is cleared from the reſidues of the combuſtion by lixiviation. This is the proceſs uſed to make the impure alkali, called *ſalin*, as we have already obſerved.

If wood remains a long time under water, it is deprived of its property of affording an alkali

kali by combuſtion; becauſe the water diſſolves the compounds which may contain it.

Marine plants afford an alkali of another nature, known by the name of Soda. Vegetables poſſeſs the power of decompoſing common ſea ſalt, and retaining its alkaline baſe. All inſipid plants are capable of affording more or leſs of ſoda, if they be raiſed on the ſea coaſt; but they periſh there in a ſhort time.

Ammoniac is likewiſe found in plants. The glutinous part of gramineous vegetables contain it, and give it out to the nitric, muriatic, and other acids, according to M. Poulletier: and nothing more is required than to triturate the eſſential ſalt of wormwood with fixed alkali, to ſeparate the volatile. This alkali appears to be one of the principles of the tetradynamia, as theſe afford it by ſimple diſtillation.

Alkalis likewiſe exiſt in plants in the ſtate of neutral ſalts. They are combined with the ſulphuric acid in old borage and in ſome aſtringent plants. The ſulphate of potaſh appears to exiſt in almoſt all vegetables, as the potaſh contains more or leſs of it; and the analyſis of tobacco has afforded me a conſiderable quantity.

Tamariſe affords the ſulphate of ſoda in ſuch abundance, that by extracting it from the aſhes of this plant, it can be afforded in very beautiful and pure cryſtals at thirty livres the quintal.

The greater turnſole, parietaria, and borage contain nitrate of potaſh.

The muriates of ſoda and of potaſh are afforded by marine plants.

We likewiſe find the alkalis combined with the acids of vegetation, ſuch as the oxalic, the tartareous, and other acids.

It appears that the ſeveral ſalts are the products of the vegetation, and peculiar effect of the organization, of vegetables. Two plants which grow in the ſame ſoil, afford very different ſalts; and each plant conſtantly affords the ſame kind. Beſides this, Homberg obſerved (Mem. Acad. Par. 1669) that the ſame ſalts were developed by plants growing in earths previouſly well waſhed, and afterwards watered with diſtilled water.

We may therefore claſs ſalts among the principles of vegetables, and no longer conſider them as accidentally contained in plants. I do not however deny that the combuſtion of a plant may not give riſe to ſome of them, and increaſe or diminiſh the proportions of others. Combuſtion muſt form combinations which did not exiſt in the plant, and deſtroy ſeveral of thoſe which exiſted before. The atmoſpheric air employed in this operation muſt unite with certain principles, and produce various reſults. The nitrogene gas which is precipitated in torrents in the focus of combuſtion, probably combines with ſome of the principles to form alkalis, and conſequently may augment the quantity of thoſe which naturally exiſt in the plant.

ARTICLE XI.

Concerning the Colouring Principles.

The object of the art of dyeing conſiſts in depriving one body of its colouring principle, to fix it upon another in a durable manner; and the ſeries of manipulations neceſſary to produce this effect, conſtitutes the art itſelf. This art is one of the moſt uſeful and wonderful of any we are acquainted with; and if there be any one of the arts which is capable of inſpiring a noble pride, it is this. It not only affords the means of imitating nature in the riches and brilliancy of her colours; but it appears to have ſurpaſſed her, in giving a greater degree of brilliancy, fixity, and ſolidity to the fugacious and tranſient colours with which ſhe has clothed the productions around us.

The ſeries of operations which conſtitute the art of dyeing, are abſolutely dependent on the principles of chemiſtry: and though it is to accidents, or the very ſlight combination of facts ſuggeſted by the compariſon of a few circumſtances, that we are indebted in this part of chemiſtry for ſeveral excellent receipts, and ſome principles; yet it is not the leſs true, that no conſiderable progreſs will ever be made, nor any ſolid foundation eſtabliſhed, but by analyſing the operations, and reducing them to general principles, which chemiſtry alone can afford. The neceſſity of eſtabliſhing proper principles is ſtill farther evinced by the uncertainty and continual trials which prevail in the manufactories. The ſlighteſt change in the nature of the ſubſtances puts the artiſt to a ſtand, inſomuch that he is incapable of himſelf of remedying the defects which ariſe. Whence follow continual loſſes, and a diſcouraging alternation of ſucceſs and diſappointment.

The little progreſs which chemiſtry has hitherto made in the art of dyeing, depends on ſeveral cauſes, which we ſhall proceed to explain.

The firſt cauſe of this ſlow progreſs depends on the difficulty of aſcertaining with any degree of certainty the nature, properties, and affinities, of the colouring principle. In order to extract this principle, we muſt be acquainted with the nature of its ſolvent; we muſt know whether the principle be in a ſtate of purity, or mixed with other parts of the vegetable; whether this colouring matter conſiſt of one principle alone, or is formed by the union of a number: we muſt alſo render ourſelves acquainted with its affinities with various kinds of ſtuff; for it is aſcertained by experience that certain colours adhere very well to wool, though they do not alter the whiteneſs of cotton. In addition to theſe neceſſary parts of knowledge, it will likewiſe be required to determine its affinity with the mordant, for alum is the mordant for ſome colours, and not others: beſides which, the action or effect of other bodies upon the colour when dyed muſt be aſcertained, in order to contrive the means of defending it from alteration, &c.

The ſecond cauſe which has retarded the application of chemiſtry to dyeing, is the difficulty the chemiſt finds of procuring opportunities of making experiments in the large way. Prejudice, which reigns deſpotically in the dye-houſe, tends to expel the chemiſt as a dangerous innovator; and the proverb, that *Experience is better than Science*, contributes to prevent the introduction of improvements into manufactories. It is very certain that a dyer, confined to the mere practical part of his buſineſs, will without controverſy produce a better ſcarlet than a chemiſt who is acquainted only with the principles; for the ſame reaſon as a ſimple workman in clock making will make a better watch than the moſt celebrated mechanic. In theſe caſes we may admit that experience is better than ſcience; but when it is required to reſolve any problem, to explain any phenomenon, or to diſcover ſome error in the complicated details of an operation, the mere artizan is at the end of his knowledge, is totally at a loſs, and would derive the greateſt advantage from the aſſiſtance of the man of ſcience.

Another cauſe of the ſlow progreſs of chemiſtry in the art of dyeing, is, that moſt of the works which treat upon this art are confined to deſcriptions of the proceſſes uſed in the manufactories. Theſe works, it muſt be admitted, poſſeſs their advantages; but they do not advance the ſcience of operations a ſingle ſtep. They only exhibit the ſketch of a country, without indicating either its relative ſituation, or the nature of its products. It has indeed been very difficult, till lately, to do more than this; becauſe the gaſes, which are ſo greatly concerned in this part of chemiſtry were unknown; becauſe the action of light and of the air, which is ſo powerful upon colours, was a fact of which neither the cauſe nor the theory could be known; and more particularly becauſe the ſalts and combinations of three, four and five principles were not known, though they very much tend to render the effects of operations on vegetables more complicated.

In order therefore to make a progreſs in the art of dyeing, we muſt ground our reaſoning on other principles. I ſhall proceed to ſketch out a plan which ſeems to me to be adapted to this purpoſe. We ſhall examine—

1. The manner in which the colours of various bodies are developed and formed.

2. The nature of the combinations of theſe ſame colours in theſe bodies, and the propereſt means of extracting them.

3. The moſt advantageous proceſſes for applying them.

1. Colours are all formed in the ſolar light. The property which bodies poſſeſs of abſorbing ſome rays, and reflecting others, forms the various tinges of colours with which they are decorated, as is proved from the experiments of Newton.

From this principle we may conſider the art of dyeing under two very different points of view.

For we may determine the colour upon a body either by changing the form and diſpoſition of its pores; ſo that it may acquire the property of reflecting a different kind of rays from thoſe which it reflected before it was ſubjected to theſe mechanical operations. Thus it is that by trituration we change the colour of many bodies; and to this cauſe it is that we muſt refer all the effects dependant on the reflexibility and refrangibility of rays. This coloration depends, as we ſee, merely on the changes produced in the ſurfaces of bodies, or the diſpoſition of their pores. The phenomena of refrangibility depend on the denſity or ſpecific gravity of bodies, according to Newton and Delaval.

The other method of cauſing a body to exhibit a determinate colour, conſiſts in transferring to the ſurface of the body ſome other body or ſubſtance which poſſeſſes the property of reflecting this known ray. This is the effect chiefly produced by dyeing.

But in what manner do the coloured bodies of the three kingdoms of nature acquire the property of conſtantly reflecting one determinate kind of rays? This is a very delicate queſtion; for the elucidation of which I ſhall bring together a few facts.

It appears that the three colours which are the moſt eminently primitive in the arts; thoſe which form all the others by their combination, and conſequently the only colours to which we need pay attention; that is to ſay, the blue, the yellow, and the red—are developed in the bodies of the three kingdoms by a greater or leſs abſorption of oxigene, which combines with the various principles of thoſe bodies.

In the mineral kingdom, the firſt impreſſion of fire, or the firſt degree of calcination, develops a blue colour, ſometimes interſperſed with yellow, as is obſervable when lead, tin, copper, iron, or other metals, are expoſed in a ſtate of fuſion to the action of the air, to haſten their cooling. This may be eſpecially obſerved in ſteel-plates which are coloured blue by heating.

Metals acquire the property of reflecting the yellow colour by combining with a greater quantity of oxigene; and accordingly we perceive this colour in moſt of them, in proportion as the calcination advances. Maſſicot, litharge, ochre, orpiment, and yellow precipitate, are inſtances of this.

A ſtronger combination of oxigene appears to produce the red; whence we obtain minium, colcothar, red precipitate, &c.

This proceſs is not uniform throughn all the bodies of the mineral kingdom; for it is natural to infer that the effects muſt be modified by the nature of the baſe with which the oxigene combines. Thus it is that in ſome of them we perceive the blue colour almoſt immediately followed by a black; as may eaſily be accounted for, on the conſideration that there is a very ſlight difference between the property of reflecting the weakeſt rays and that of reflecting none at all.

To give additional force to the obſervations here made, we may alſo take notice that the metals themſelves are moſt of them colourleſs, and become coloured by calcination; that is to ſay, by the fixation and combination of oxigene.

The effects of the combination of oxigene are equally evident in the mineral as in the vegetable kingdom; and, in order to convince ourſelves of this, we need only follow the operations in the method of preparing and developing the principal blue colours, ſuch as indigo, paſtel, turnſole, &c.

Indigo is extracted from a plant known by the name of Anillo by the Spaniards, and the Indigo Plant by us. It is the *Indingofera tinctoria* of *Linnæus.* It is cultivated at Saint Domingo, in the Antilles, and in the Eaſt Indies. The boughs are cut every two months, and the root laſts two years. The plant is laid to ferment in a trough called the ſteeping trough, which is filled with water. At the end of a certain time the water heats, emits bubbles, and becomes of a blue colour. It is then paſſed into another veſſel or trough, called the beating trough (batterie), where the fluid is ſtrongly beaten or agitated by a mill with pallets, to condenſe the ſubſtance of the indigo. As ſoon as the water is become inſipid, it is drawn off; and the depoſition of the fecula is made in a third veſſel, called the ſettling trough (repoſoir), where it dries, and is taken out to form the loaves diſtributed in commerce.

The paſtel is a colour which is extracted in Upper Languedoc, by fermenting the leaves of the plants after having firſt bruiſed them. The fermentation is promoted by moiſtening them with the moſt putrid water that can be procured.

The woad is prepared in Normandy in the ſame manner as the paſtel.

Turnſole is prepared at Grand Galargues by ſoaking rags in the juice of the croton tinctorium, and afterwards expoſing them to the vapour of urine or dung.

We likewiſe obſerve that the firſt degree of combination of oxigene with oil (in combuſtion) develops the blue colour for the inſtant.

The blue colour is formed in dead vegetables only by fermentation. Now in theſe caſes there is a fixation of oxigene. This oxigene combines with the fecula in indigo, with an extractive principle in turnſole, &c.; and moſt colours are likewiſe ſuſceptible of being converted into red by a greater quantity of oxigene. Thus it is that turnſole reddens by expoſure to air, or to the action of acids: becauſe the acid is decompoſed upon the mucilage, which is the receptacle of the colour; as may be ſeen in ſyrup of violets, upon which the acids are decompoſed when concentrated. The ſame thing does not happen when a fecula is ſaturated with oxigene, and does not admit of the decompoſition of the acid. Hence it is that indigo does not become red by acids, but is, on the contrary, ſoluble in them. It is likewiſe for the ſame reaſon that we obſerve a red colour developed in vegetables in which an acid continually acts, as in the leaves of the oxalis, of the virgin vine, the common ſorrel, and the ordinary vine. Hence alſo it happens that acids brighten moſt of the red colours; and that a very highly charged metallic oxide is uſed as the mordant for ſcarlet.

We find the ſame colours developed in the animal kingdom by the combination of the ſame principle. When fleſh meat putrefies, the firſt impreſſion of the oxigene conſiſts in producing a blue colour; whence the blue appearance of mortifications, of fleſh becoming putrid, of game too long kept, or the appearance which in our kitchens in France is called *cordon bleu.* This blue colour is ſucceeded by red, as is obſerved in the preparation of cheeſes, which become covered with a mouldineſs at firſt of a blue colour, but afterwards becoming red: I have purſued theſe phenomena in the preparation of cheeſes at Roquefort. The combination of oxigene, and the proportional quantity which enters into ſuch combination, determine therefore the property of reflecting any particular rays of light. But it may eaſily be underſtood that the colour muſt be ſubject to variation, according to the nature of the principle with which it combines; and this points out a ſeries of very intereſting experiments that remain to be made.

All the phenomena of the combination of air, with the ſeveral principles in different proportions, may be obſerved in the flame of bodies actually on fire. This flame is blue when the combuſtion is ſlow; red, when ſtronger and more complete; and white, when ſtill more perfect. For theſe final degrees of oxidation in general produce a white colour, becauſe all the rays are then equally reflected.

From the foregoing facts we may conclude that the blue ray is the weakeſt, and is conſequently reflected by the firſt combination of oxigene. We may add the following fact to thoſe we have already exhibited. The colour of the atmoſphere is blueiſh: the light of the ſtars is blue, as M. Mariotte has proved, in the year 1678, by receiving the light of the moon upon white paper: the light of a clear day reflected into the ſhade by ſnow, is of a fine blue, according to the obſervations of Daniel Major (Ephem. des Curioſ. de la Nature, 1671, premier Dec.).

The colouring principle is found in vegetables in four ſtates of combination—1. With the extractive principle. 2. With the reſinous principle. 3. With a fecula. 4. With a gummy principle.—Theſe four ſtates in which we find the colouring principle, indicate to us the means of extracting it.

A. When the receptacle of the colour is of the nature of extracts, water is capable of diſſolving the whole: ſuch is that of logwood, turnſole, madder, cochenille, &c. Nothing more is neceſſary than to infuſe theſe ſubſtances in water, for the purpoſe of extracting their colouring principle. If any ſtuff be plunged in this ſolution, it will be covered with a body of colour, which will be a mere ſtain, that may be again cleared off by water. To obviate this inconvenience, it has therefore been found neceſſary to impregnate the ſtuffs on which the colours were intended to be applied with ſome ſalt or other principle, which might change the nature of the colouring matter, and give it fixity, by depriving it of its ſolubility in water. It is this ſubſtance which is diſtinguiſhed by the name of Mordant. It is likewiſe neceſſary that the mordant ſhould have an affinity with the principle of colour, in order that it may become its receiver. Hence it ariſes that moſt of theſe colours, ſuch as turnſole, Braſil wood, &c. are not fixed by theſe mordants; hence alſo it ariſes that cochenille does not form a fine ſcarlet, unleſs it has tin for its mordant. It is neceſſary, moreover, that the mordant have a due relation to the nature of the ſtuff; for the ſame compoſition which gives a fine ſcarlet colour to wool, gives a colour of wine lees to ſilk, and does not even change the white colour of cotton.

B. There are certain reſinous colouring matters ſoluble in ſpirit of wine: ſuch are the pharmaceutical tinctures: they are uſed only in the arts for dyeing ribbons. There are other colouring matters combined with feculæ, which water does not diſſolve: rocou, archil, indigo, and the red colour of oriental ſaffron, are of this kind.

Rocou is a reſinous fecula obtained by macerating the ſeeds of an American tree called Urucu in water. In this operation the extractive part is deſtroyed by fermentation, and the reſinous fecula is collected in a paſte of a deep yellow colour. The paſte of rocou, diffuſed in water with the impure alkali called *cendres gravelées*, affords a fine orange colour.

Archil is a paſte prepared by macerating certain moſſes and lichens in urine with lime. Alkalis extract a violet colour. Archil is made in Corſica, in Auvergne, at Lyons, &c.

The archil of the Canaries is leſs charged with lime. That which I procured, exhibited in its texture the fibres of the plant, not completely decompoſed by the fermentation. The archil of the Canaries, or the archil in the herb, is afforded by the lichen called, *Orcella, rocella, lichen fruticuloſus, ſolidus, aphyllus, ſubramoſus, tuberculis alternis, Linnæi*. The parella or archil of Auvergne is made with the *lichen parellus* Linnæi.

The colouring matters of this claſs are all ſoluble in alkali or lime; and theſe are the ſubſtances uſed to diſſolve them in water, and precipitate them upon ſtuffs. Lime is the true ſolvent of indigo; but alkali is the ſolvent of other ſubſtances of the ſame claſs. For example: when it is required to make uſe of the colouring matter of baſtard ſaffron, the firſt proceeding conſiſts in waſhing it in much water, to clear it of the extractive and yellowiſh principle, which is very abundant; and the reſinous principle is afterwards diſſolved by means of alkali, from which ſolvent it is precipitated upon the ſtuffs by means of acids. In this manner it is that the poppy-coloured ſilk is made. This reſinous principle may alſo be combined with talc, after it has been extracted by an alkali, and precipitated by an acid; in which caſe the reſult is vegetable red. To make this pigment, the yellow colour of ſaffron or carthamus is firſt extracted by means of waſhing. Five or ſix per cent. of its weight of ſoda is mixed with the reſidue; and cold water is poured on, which takes up a yellow matter; and this, by the addition of lemon juice, depoſits a red fecula. The red fecula, mixed with levigated talc, and moiſtened with lemon juice, forms a paſte, which is put into pots to dry. If the red be ſoluble in ſpirit of wine, it is vegetable; but if not it is mineral, and is uſually vermilion.

Acids may be uſed inſtead of alkalis in fixing ſome of theſe colours upon ſtuffs. To make a permanent blue, inſtead of diſſolving indigo by means of lime, it is ſometimes diſſolved in oil of vitriol. This ſolution is poured into the bath, and the alumed ſtuff is paſſed through it. Flannels are dyed blue at Montpellier in this way. This operation depends merely on an extreme diviſion of the indigo by the acid.

D. There are ſome colouring principles fixed by a reſin; but which, by the aſſiſtance of extractive matter, may be ſuſpended by water. The ſtuffs are boiled in this ſolution; the reſinous part applies itſelf to them, and adheres with ſufficient ſolidity not to be again carried off by water.

No preparation is required to dye with theſe ingredients, nothing more being neceſſary than to boil the ſtuff in a decoction of the colour. The principal ſubſtances of this kind are, the huſk of walnuts, the roots of the walnut-tree, ſumach, ſantal, the bark of elder, &c. All theſe ſubſtances, which require no mordants, afford only a buff-coloured tinge, which dyers call Root Colours. The colouring matter of certain vegetables may likewiſe be extracted by oils. In this way oils are coloured red by infuſing alkanet, or the root of a certain ſpecies of bugloſs in them.

In order to apply colouring matter properly upon any ſtuff, it is neceſſary to prepare the ſtuff, and diſpoſe it to receive the colouring principle. For this purpoſe it muſt be waſhed, bleached, and cleared of that glutinous matter which defends it from the deſtructive action of the air while it grows on the animal which affords it; and impregnated with the mordant which fixes the colour, and gives it peculiar properties.

A. The firſt operation required to diſpoſe a ſtuff to receive colour, is bleaching; becauſe the whiter it is, the more natural and accurate will be the colour it takes. If this precaution be not taken, the ſucceſs will be uncertain. To bleach piece-goods, the operator is ſatisfied with boiling them in an alkaline lixivium, and expoſing them afterwards to the air, to render the whiteneſs more perfect. This operation depends on the action of the oxigene, which combines with the colouring principle, and deſtroys it; as is evidently demonſtrated by the late experiments of M. Berthollet on the oxigenated muriatic acid, which bleaches cloths and cottons with ſuch facility, that it is already uſed for this purpoſe in ſeveral manufactories.

Cotton is bleached in ſome manufactories by a very ingenious proceſs. A boiler is firmly ſet in maſonry, and a cover fitted to it in the ſtrongeſt manner; this boiler has an elliptical figure. Alkali rendered cauſtic by lime is put into the bottom of this veſſel; and the goods intended to be bleached are put into a baſket, which prevents their touching the ſides of the boiler. When the piece-goods are properly placed, the covering is fixed on, which is pierced by a very ſmall aperture, to permit a portion of the aqueous vapour to eſcape. A degree of heat much ſuperior to that of boiling water is excited in the ſolution of potaſh; and the heat, aſſiſted by the corroſive action of the potaſh in this kind of Papin's digeſter, deſtroys the colouring principle of the cottons, and gives them the utmoſt whiteneſs.

B. That kind of gluten which envelops almoſt every animal ſubſtance, but more eſpecially raw ſilk, is inſoluble in water and in alcohol. It is only attacked by alkalis and ſoaps; and for this purpoſe the operation of cleanſing is uſed. Any ſtuff may be cleared of its glutinous part by boiling or even digeſting it in a ſolution of alkali: but it has been obſerved that a pure alkali alters the goodneſs and quality of the ſtuff; for which reaſon ſoaps have been ſubſtituted in its ſtead. For this purpoſe the ſtuff is ſteeped in a ſolution of ſoap, heated to a leſs degree than boiling. The academy of Lyons, in the year 1761, propoſed a prize for the means of clearing raw ſilks without ſoap. It was adjudged to M. Rigaut, of St. Quentin, who propoſed a ſolution of ſalt of ſoda.

It has been lately aſcertained that water, heated above the degree of ebullition, is capable of diſſolving this colouring principle. A boiler ſimilar to that which I have juſt deſcribed, may be uſed for this purpoſe.

In order to bleach cotton, and diſpoſe it for the dyeing proceſſes, it is cleanſed by means of a liquid ſoap made of oil and ſoda.

The piece-goods are cleared by this boiling from the varniſh, which would prevent the colour from applying and fixing itſelf in a permanent manner; at the ſame time that it opens the pores of the ſtuff for the better reception of the colour.

When the piece is thus prepared, its pores being very open, and its colour very white, nothing remains to be done previous to the application of the dye, but to impregnate it with the mordant or principle which is to receive the colour; and change its nature ſo much, that neither water, ſoap, nor any of the reagents uſed as proofs, may be capable of extracting it. It is neceſſary therefore—1. That the mordant itſelf ſhould be very white, that it may not alter the colour preſented to it. 2. That it be not ſubject to corruption; and for this purpoſe it muſt be ſought among the earths and metallic oxides. 3. That it be in a ſtate of extreme diviſion, in order that it may fix itſelf in the pores. 4. That it be inſoluble in water and the other reagents. 5. That its affinity with the colouring matter and the ſtuff be very great.

Alum, and the muriate of tin, are the two ſalts whoſe baſes unite theſe properties in the moſt efficacious manner. The ſtuffs having undergone the previous operations, are therefore ſteeped in ſolutions of theſe ſalts; and when they are impregnated, they are paſſed through the colouring bath: and by the decompoſition, or change of principles between the mordant and the principle which holds the colour in ſolution, the colour is precipitated on the baſe of the mordant, and adheres to it.

Certain vegetable ſubſtances are likewiſe diſpoſed to take ſome colours by animalizing them. In this way cows dung and bullocks blood are uſed in dyeing cotton; for it is a decided fact that animal ſubſtances take colours better than vegetables.

ARTICLE XII.

Concerning the Pollen, or Fecundating Powder of the Stamina of Vegetables.

Modern diſcoveries and obſervations have pointed out the ſexual parts of plants; and we find nearly the ſame forms in the organs, the ſame means in the functions, and the ſame characters in the prolific humours, as in animals.

The prolific humour in the male part is elaborated by the anthera; and as the organs of the plant do not admit of an actual intromiſſion of the male into the female, becauſe vegetables are not capable of loco-motion, nature has beſtowed on the fecundating ſeed the character of a powder; which the agitation of the air, and other cauſes, may carry away and precipitate upon the female. There is a degree of elaſticity in the anthera, which cauſes it to open, and eject the globules. It has even been obſerved that the piſtil opened at the ſame time, to receive the pollen, in certain vegetables. The reſources of nature to aſſure the fecundation are admirable. The male and female parts almoſt always repoſe in the ſame flower; and the petals are always diſpoſed in the moſt advantageous manner to favour the reproduction of the ſpecies. Sometimes the male and female are upon the ſame individual, but placed upon different flowers; at other times both are attached to iſolated and ſeparate individuals, and then the fecundation is made by the pollen which the wind or air detaches from the antheræ, and tranſmits to the female.

The fecundating powder has almoſt conſtantly the ſmell of the ſpermatic liquor of animals. The ſmell of cabbages in bloſſom, of the cheſtnut tree, and moſt other vegetables, exhibits this analogy to ſuch a degree, that the one odour might even be miſtaken for the other.

The pollen is generally of a reſinous nature, ſoluble in alkalis and in alcohol. Like reſins, it is inflammable; and the *aura* which is formed around certain vegetables at the time of fecundation, may be ſet on fire, as was obſerved by Mademoiſelle Linné in the fraxinella.

Nature, which has employed leſs œconomical means in the fecundation of plants, and who entruſts theſe operations almoſt to chance, ſince ſhe delivers the fecundating powder to the winds,

winds, muſt of courſe have been prodigal in the formation of this humour, more eſpecially for the trees of the monoecia and dioecia genera, where the production is more expoſed to accidental impediments. Hence we may account for thoſe pretended ſhowers of ſulphur, which are never common but in ſuch diſtricts as abound with the hazel, filbert, and pine-trees.

As the pollen could not be expoſed by nature to the varying temperatures of the atmoſphere, ſhe has facilitated its development in the moſt rapid manner. A warm ſun very frequently ſuffices to open the concealed organs of the plant, to develop and procure its fecundation. On this account the author of *Les Etudes de la Nature* affirms, that the coloration of plants is deſigned to reflect the light more vividly, and moſt flowers affect the moſt advantageous form to concentrate the ſolar rays on the parts of generation.

The parts employed in theſe functions are endued with an aſtoniſhing degree of irritability. M. des Fontaines has made ſome very intereſting obſervations on this ſubject; and the agitated motions which ſome plants affect in order to follow the courſe of the ſun, are determined by nature, in order that the great work of generation, favoured by the ſun, may be accompliſhed in the leaſt poſſible time.

Con-

Concerning Wax.

The wax of bees is merely the pollen very little altered. Theſe inſects have their *femurs* provided with rugoſities to bruſh the pollen from the antheræ, and convey it to their neſts.

There appears to exiſt in the very texture of ſome flowers, which are rich in fecundating powder, a matter analogous to wax, which may be extracted by aqueous decoction. Such are the male catkins of the betula alnus, thoſe of the pine, &c. the leaves of roſemary, of officinal ſage; the fruits of the mirica cerifera, ſuffer wax to tranſude through the pores.

It appears that wax and the pollen have for their baſis a fat oil, which paſſes to the ſtate of reſin by its combination with oxigene. If the nitric or muriatic acid be digeſted upon fixed oil for ſeveral months, it paſſes to a ſtate reſembling wax.

Wax, by repeated diſtillations, affords an oil which poſſeſſes all the properties of volatile oils. It is reduced into water and carbonic acid by combuſtion.

The colouring matter of wax appears to be of the ſame nature as that of ſilk; it is inſoluble in water and in alcohol. In the arts, wax is bleached by dividing it prodigiouſly; for which purpoſe it is poured in fuſion upon the ſurface of a cylinder, which revolves at the ſurface of water. The wax which falls applies itſelf to the ſuperficies, and is reduced into very thin flakes or ribbons. It is afterwards expoſed to the air upon tables, taking care to ſtir it from time to time, and by this means it becomes white.

Alkalis diſſolve wax, and render it ſoluble in water. It is this ſaponaceous ſolution which forms the punic wax. It may be uſed as the baſis of ſeveral colours; and may be made into an excellent paſte for waſhing the hands. It is likewiſe applied with a bruſh upon ſeveral bodies: but it would be highly advantageous if it could be deprived of its ſolvent, which conſtantly acts, and is the cauſe why it cannot be applied to ſeveral uſes, in which otherwiſe it might be found advantageous.

Ammoniac likewiſe diſſolves it; and as this ſolvent is evaporable, it ought to be preferred when it is propoſed to uſe the wax as a varniſh.

ARTICLE XIII.

Concerning Honey.

Honey, or the nectar of flowers, is contained chiefly in the baſe of the piſtil, or female organ. It ſerves as food for moſt inſects which have a proboſcis. Theſe animals plunge their proboſcis into the piſtil, and ſuck out the nectar. It appears to be a ſolution of ſugar in mucilage: the ſugar is ſometimes precipitated in cryſtals, as in the nectar of the flower of balſamina.

The nectar undergoes no alteration in the body of the bee, ſince we can form honey by concentrating the nectar. It retains the odour, and not unfrequently the noxious qualities of the plant which affords it.

The ſecretion of the nectar is made during the ſeaſon of fecundation. It may be conſidered as the vehicle and recipient of the fecundating duſt, which facilitates the burſting of the globules, filled with this fecundating powder: for Linnæus and Tournefort have both obſerved that nothing more is required than to expoſe the pollen upon water, to aſſiſt the development. All the internal part of the ſtyle of the piſtil is impregnated with it. And if the internal part of the female organs be dried by heat, the pollen no longer fecundates.

Honey exudes from all the female parts, but particularly from the ovaria. Pores may even be obſerved in hyacinths, through which it flows.

Such flowers as have only the male parts do not in general afford honey; and the organs which afford the nectar dry up and wither from the moment the act of conception is accompliſhed. Honey may therefore be conſidered as neceſſary to fecundation: it is the humour afforded by the female to receive the fecundating powder, and facilitate the opening and exploſion of the ſmall bodies which contain the pollen; for it has been obſerved that theſe bodies open the moment they touch the ſurface of any liquid which moiſtens them.

ARTICLE XIV.

Concerning the Ligneous Part of Vegetables.

Chemiſts have conſtantly directed their attention to the analyſis of vegetable juices: but they appear to have completely neglected the ſolid part of the vegetable, which in every point of view is entitled to particular attention. It is this ligneous portion which forms the vegetable fibre; and this matter not only conſtitutes the baſis of the vegetable, but is likewiſe developed in circumſtances which depend on the vital functions of the plant. It forms the pulp of ſeeds, the lanuginous covering which overſpreads certain plants, &c. The character of the ligneous part is, an inſolubility in water and almoſt every other menſtruum. The ſulphuric acid only blackens it, and is decompoſed upon it, as is likewiſe the nitric acid. But one very peculiar character of this principle is, that the concourſe of air and water alters it very difficultly; and that, when it is well deprived of all its moiſture, it abſolutely reſiſts every kind of fermentation; inſomuch that it would be indeſtructible, if inſects had not the property of gnawing and feeding upon it. It appears that the vegetable fibre conſiſts of the baſis of mucilage, hardened by its combination with a greater quantity of oxigene. Several reaſons lead us to adopt this idea. In the firſt place, the diluted nitric acid being put to digeſt upon fecula, is decompoſed, and cauſes the fecula to paſs to a ſtate reſembling that of ligneous matter. I have obſerved, in the ſecond place, that thoſe fungi which grow in ſubterraneous places void of light, and are reſolved into a very acid water, if left in a veſſel, acquire a greater quantity of the ligneous principle, in proportion as they are expoſed by degrees to the light; at the ſame time that the acid is diminiſhed by decompoſition, and at length diſappears.

The tranſition of mucilage to the ſtate of ligneous matter is very evident in the growth of vegetables. The cellular envelop which is immediately covered by the epidermis exhibits nothing but mucilage and glands; but by degrees it hardens, forms a ſtratum of the cortical coating, and at laſt concludes by becoming one of the ligneous rings.

We obſerve this tranſition in certain plants which are annual in cold climates, and vivacious in temperate climates. In the former they are herbaceous, becauſe the periodical return of the cold weather does not permit them to develop themſelves. In the ſecond they become arboreſcent; and the progreſs of time hardens the mucilage, and forms ligneous coatings.

The induration of the fibrous part may be accelerated by cauſing the air and light to act more ſtrongly upon it. M. de Buffon has obſerved that, when a tree is deprived of its bark, the external part of the wood which is expoſed to the air acquires a conſiderable degree of hardneſs; and trees thus prepared form pieces of carpentry much more ſolid than thoſe which have not undergone ſuch preparation.

It is probably owing to the large quantity of pure air with which the fibrous matter is loaded, that it is not diſpoſed to putrefy: and it is in conſequence of this moſt valuable property of not being ſubject to corruption, that arts have been invented for clearing it of all fermentable principles of the vegetable kingdom, to obtain it in its greateſt purity in the fabrication of cloths, paper, &c. We ſhall again return to theſe objects, when we treat of the alterations to which the vegetable kingdom is ſubject.

ARTICLE XV.

Concerning other fixed Principles of the Vegetable Kingdom.

The volatile oil of horſe-radiſh had formerly afforded ſulphur, which is depoſited by ſtanding, according to the obſervation of ſome chemiſts; but M. Deyeux has taught us to extract this inflammable principle from the root of the herb patience. Nothing is required to be done but to raſp the root, boil it, take off the ſcum, and dry it. This ſcum affords much ſulphur in ſubſtance; and it is perhaps to this principle that theſe plants owe their virtue, ſince they are uſed in ſkin diſorders.

Vegetables in their analyſis likewiſe preſent us with certain metals, ſuch as iron, gold, and manganeſe. The iron forms near one-twelfth of the weight of the aſhes of hard wood, ſuch as oak. It may be extracted by the magnet. It does not appear to exiſt in a perfectly diſengaged ſtate in the vegetable; nevertheleſs we read, in the Journaux de Phyſique, an obſervation in which it is affirmed, that it was found in metallic grains in fruits. The iron is uſually held in ſolution in the acids of vegetation, from which it may be precipitated by alkalis. The exiſtence of this metal has been attributed to the wearing of ploughſhares, and other inſtruments of huſbandry, and to the faculty which plants poſſeſs of imbibing it with their nutritive juices. The Abbé Nolet and others have embraced this unphiloſophical notion. It is the ſame with the iron as with the other ſalts. They are produced by vegetation; and vegetables watered with diſtilled water afford it as well as others.

Beecher and Kunckel aſcertained the preſence of gold in plants. M. Sage was invited to repeat the proceſſes by way of aſcertaining the fact. He found gold in the aſhes of vine twigs, and announced it to the public. After this chemiſt, moſt perſons who have attended to this object have found gold; but in much leſs quantity than M. Sage had announced. The moſt accurate analyſes have ſhewn no more than two grains: whereas M. Sage had ſpoken of ſeveral ounces in the quintal. The proceſs for extracting gold from the aſhes conſiſts in fuſing them with black flux and minium. The lead which is produced is then cupelled, to aſcertain the ſmall quantity of gold with which it became alloyed in this operation.

Scheele has alſo obtained mangaueſe in the analyſis of vegetable aſhes. His proceſs conſiſts in fuſing part of the aſhes with three parts of fixed alkali, and one-eighth of nitrate of potaſh. The fuſed matter is boiled in a certain quantity of water. The ſolution being then filtered, is ſaturated with ſulphuric acid, and at the end of a certain time manganeſe falls down.

Lime conſtantly enough forms ſeven-tenths of the fixed reſidue of vegetable incineration. This earth is uſually combined with the carbonic acid. Scheele has proved that it effloreſces in this form on the bark of guaiacum, the aſh, &c. It is likewiſe very often united with the acid of vegetation. It appears to be formed ed by an alteration of the mucilage, more advanced than that which forms the fecula, which has ſome analogy with this earth. We evidently ſee the tranſition of mucilage to the ſtate of earth in teſtaceous animals. We obſerve the mucilage putrefy at its ſurface, with ſo much the more facility as it is purer; as we may judge by a compariſon of the aſteriæ, the ſea hedge-hog, the crab, &c.

Next to lime, alumine is the moſt abundant earth in vegetables, and next magneſia. M. Darcet has obtained, from one pound of the aſhes of beech, one ounce of the ſulphate of magneſia, by treating them with the ſulphuric acid. This earth is very abundant in the aſhes of tamariſc. Siliceous earth likewiſe exiſts, but leſs abundantly. The leaſt common of all is the barytes.

ARTICLE XVI.

Of the common Juices extracted by Inciſion or Expreſſion.

The vegetable juices hitherto treated of are peculiar ſubſtances contained in vegetables, and poſſeſſing ſtriking characters, by which they are diſtinguiſhable from every other humour.

But we may at once extract from vegetables all the juices they contain; and this mixture of various principles may be obtained by ſeveral methods. Simple inciſion is ſometimes ſufficient; but expreſſion is equally uſed.

The juices of vegetables vary according to the reſpective nature of the plants. They are more abundant in ſome than in others. Age modifies them. Young trees in general have moſt ſap; and this ſap is milder, more mucilaginous, and leſs charged with oil and reſin. The ſap varies according to the ſeaſon. In the ſpring the plants draw up with avidity the juices afforded by the air and the earth; theſe juices eſtabliſh a plethora every where, from which reſults a conſiderable growth of the individual, and ſometimes a natural extravaſation. If in the time of plethora inciſions be made in any part of the vegetable, all the abundant ſap eſcapes by the aperture; and this fluid is almoſt always clear, and without ſmell. But by degrees the plant elaborates theſe juices, and gives them peculiar characters. In the ſpring the ſap in the body of the vegetable preſents only a ſlight alteration of the nutritive juices; but in the ſummer the whole is elaborated, all is digeſted, and then the ſap poſſeſſes characters very different from thoſe it poſſeſſed during the ſpring ſeaſon.

If inciſions be now made in the tree, the juices obtained are accordingly very different: and for this reaſon it is that the juices diſperſed in commerce are extracted during the ſummer.

The conſtitution of the air equally influences the nature of vegetable juices. A rainy ſeaſon oppoſes the development of the ſaccharine principle, as well as the formation of reſins and aromatic ſubſtances. A dry ſeaſon affords little mucilage, but much reſin and aromatic principle; hot weather decompoſes the mucilage, and favours the development of reſins, ſaccharine matter, and aroma; but a cold ſeaſon does not permit the formation of any principle but mucilage: and as the mucilage is the principle of increaſe of bulk in plants, the whole of this ſubſtance is employed for that purpoſe; while the heat and light modify the ſame mucilage, and cauſe it to paſs to the ſtate of oil, reſin, aroma, &c. Hence probably it is that trees have a more agreeable appearance in cold than in burning climates; and that the trees in this latter ſituation abound with aromatic, oily, and reſinous principles. In the vegetable as in the animal kingdom, ſpirit appears to be the portion of the ſouthern climates; while force and ſtrength are attributes of the northern.

Con-

Concerning the Juices extracted by Inciſion.

The juice contained in plants, and known by the name of Sap, is diſperſed through the cellular tiſſue, incloſed in the veſſels, or depoſited in the utricles; and there is a communication exiſting, which, when any part of the vegetable is wounded, cauſes the abundant juices to flow through the aperture; not indeed ſo ſpeedily nor ſo completely as in animals; becauſe the humours do not poſſeſs ſo rapid a motion, and becauſe there is leſs connection between the ſeveral organs in vegetables than in animals. The ſap is a confuſed mixture of all the principles of vegetables. The oil and the mucilage are confounded with the ſalts. It is, in a word, the general humour of vegetables, in the ſame manner as the blood in animals. In the preſent place we ſhall ſpeak only of manna and opium.

1. Manna.—Several vegetables afford manna; it is extracted from the pine, the fir, the maple, the oak, the juniper, the fig, the willow, the olive, &c. but the aſh, larch, and the alhagi, afford it in the largeſt quantities. L'Obel, Rondelet, and others, have obſerved at Montpellier, upon the olive trees, a kind of manna, to which they have given the name of œlio-

meli. Tournefort collected it from the ſame trees at Aix, and at Toulon.

The aſh which affords manna grows naturally in all temperate climates; but Calabria and Sicily appear to be the moſt natural countries to this tree; or at leaſt it is only in theſe countries that it abundantly furniſhes the juice called Manna in commerce.

The manna flows naturally from this tree, and attaches itſelf to its ſides in the form of white tranſparent drops; but the extraction of this juice is facilitated by inciſions made in the tree during ſummer: the manna flows through theſe apertures upon the trunk of the tree, from which it is detached with wooden inſtruments. Care is likewiſe taken to inſert ſtraws, or ſmall ſticks of wood, into theſe inciſions; and the ſtalactites which hang from theſe ſmall bodies are ſeparated, and known in commerce by the name of Manna in Tears: the ſmalleſt pieces form the manna in ſorts or flakes; and the common or fat manna is of the worſt quality, becauſe the moſt contaminated with earth and other foreign ſubſtances. The aſh ſometimes affords manna in our climates, ſpecimens of which I have ſeen collected in the vicinity of Aniane.

The larch, which grows abundantly in Dauphiny, and the environs of Briançon, likewiſe affords manna. It is formed during the ſummer on the fibres of the leaves, in white friable grains, which the peaſants collect and put into pots, which they keep in a cool place. This manna is of a yellow colour, and has a very nauſeous ſmell.

The alhagi is a kind of broom, which grows in Perſia. A juice tranſudes from its leaves, in the form of drops of various ſizes, which the heat of the ſun indurates. An intereſting account of this tree may be ſeen in Tournefort's Travels. This manna is known in the Levant, in the town of Tauris, by the name of Tereniabin.

The manna moſt frequently uſed is that of Calabria. Its ſmell is ſtrong, and its taſte ſweetiſh and nauſeous: if expoſed on hot coals, it ſwells up, takes fire, and leaves a light bulky coal.

Water totally diſſolves it, whether hot or cold. If it be boiled with lime, clarified with white of egg, and concentrated by evaporation, it affords cryſtals of ſugar.

Manna affords by diſtillation water, acid, oil, and ammoniac; and its coal affords alkali.

This ſubſtance forms the baſis of moſt purgative medicines.

2. Opium.—The plant which affords opium is the poppy, which is cultivated in Perſia and

Aſia Minor. To extract this precious medicine, care is taken to cut off all the flowers which would load the plant, and to leave that only which correſponds with the principal ſtem. At the beginning of ſummer, when the poppy-heads are ripe, inciſions are made quite round them, from which tears flow that are carefully collected. This opium is the pureſt, and is retained in the country for various uſes. That which comes to us is extracted by preſſure from the ſame heads. The juice thus obtained is wrapped up, after previous drying, in the leaves of the poppy, and comes to us in the form of circular flattened cakes.

In our laboratories it is cleared from its impurities by ſolution in hot water, filtration, and evaporation to the conſiſtence of an extract. This is the extract of opium.

Opium contains a ſtrong and narcotic aroma, from which it is impoſſible to clear it, according to Mr. Lorry. It likewiſe contains an extract ſoluble in water, and a reſin; together with a volatile concrete oil, and a peculiar ſalt.

By long digeſtion in hot water the volatile oil becomes attenuated, is diſengaged, and carries the aroma with it; ſo that by this means the oil and aroma may be ſeparated, at leaſt for the moſt part. It has been obſerved that opium deprived of this oil, a portion of its aroma, and its reſin, preſerved its ſedative virtue, without being narcotic and ſtupifying. We are indebted to Baumé for a ſeries of intereſting reſearches on this ſubject. He boiled four pounds of ſliced opium in between twelve and fifteen pints of water, for half an hour. The decoction was ſtrained with preſſure; the dregs were exhauſted by ebullition with more water. All theſe waters were mixed together, and reduced by evaporation to ſix pints. The liquor was then put into a cucurbit of tin, and digeſted on a ſand-bath for ſix months, or during three months night and day. Care was taken to add water as the evaporation proceeded; and the bottom of the veſſel was ſcraped from time to time, to diſengage the reſinous matter which ſubſided. When the digeſtion was finiſhed, the liquor was filtered, the reſidue carefully ſeparated, and the water evaporated to the conſiſtence of an extract.

If the ſalt be required to be ſeparated, the evaporation muſt be ſuſpended when the fluid is reduced to one pint. An earthy ſalt falls down by cooling, which is of a ruddy appearance, and has the form of ſcales mixed with needled cryſtals.

By this long but judicious proceſs, the oil is firſt ſeparated; which after three or four days riſes to the ſurface of the liquor, where it forms an adheſive pellicle, like turpentine. This pellicle is gradually diſſipated, and diſappears at the end of a month, nothing more being ſeen than a few drops from time to time. In proportion as the oil is diſſipated, the reſin, which formed a ſoap with it, is precipitated.

Mr. Baumé has calculated that theſe principles exiſt in the following proportions:—Four pounds of common opium afford one pound once ounce of marc or inſoluble matter, one pound fifteen ounces of extract, twelve ounces of reſin, one gros or dram of ſalt, three ounces ſeven gros of denſe oil or aroma.

Mr. Bucquet propoſed to extract the ſedative principle, by diſſolving it in the cold, and afterwards evaporating it; Mr. Joſſe, by agitating it in cold water; Meſſrs. De Laſſone and Cornette, by diſſolving, filtering it ſeveral times, and always evaporating it to the conſiſtence of an extract.

The ſedative principle is a medicine of the greateſt value, becauſe it does not produce that drunkenneſs and ſtupor which are too commonly the effects of crude opium.

When a plant does not afford its juice by inciſion, this may happen either becauſe the quantity is too ſmall, or becauſe its conſiſtence is not ſufficiently fluid, or becauſe there is not a ſufficiently perfect communication between the veſſels of the plant to permit the flowing of all the juice. In theſe caſes the deſired effect may be produced either by ſimple mechanical preſſure, as in extracting the juice of hypociſtus and acacia; or by the aſſiſtance of water, which ſoftens the texture of the vegetable, at the ſame time that it diſſolves and carries off the juice.

Concerning Vegetable Juices extracted by Preſſure.

The ſucculent vegetables afford their juice by ſimple preſſure; and the method of performing this operation is nearly the ſame in all plants. When it is intended to extract the juice of a plant, it is waſhed, cut into ſmall pieces, pounded in a marble mortar, put into a linen bag, and preſſed in a preſs.

There are ſome ligneous plants, ſuch as ſage, thyme, and the leſſer centaury, whoſe juices cannot be extracted without the addition of a ſmall quantity of water; there are other very ſucculent plants, ſuch as borage, bugloſs, and chicory, whoſe juices are ſo viſcid and mucilaginous, as not to paſs through a cloth unleſs a ſmall quantity of water be added during the pounding. Inodorous plants may likewiſe be left to macerate, in order to prepare them for the extraction of their juices. The vegetable juices may be clarified by ſimple repoſe, or by filtration; when very fluid, by white of egg, or animal lymph, boiled with them; and when the juices contain principles which may be evaporated, ſuch as thoſe of ſage, balm, marjoram, &c. the vial which contains the juice is plunged in boiling water, after having cloſed it with a paper with a hole pierced through it; and when the juice is clarified, it is taken out, dipped in cold water, and decanted.

The juice of acacia is extracted from the ſame tree which affords gum arabic. The fruits of this tree are collected before they are ripe; then pounded, preſſed, and the juice dried in the ſun: it forms balls of a blackiſh brown internally, redder externally, and of an aſtringent taſte.

A juice is prepared with unripe ſloes, which is ſold under the name of German Acacia, and does not differ much from that of Egypt.

The juice of hypociſtus is extracted from a paraſitical plant which grows on the ciſtus in the iſland of Crete. The fruit is pounded, the juice extracted by preſſure, and thickened in the ſun; it becomes black, and of a firm conſiſtence.

Theſe two laſt-mentioned juices are uſed in medicine as aſtringents.

SECTION IV.

Concerning ſuch Principles as eſcape from Vegetables by Tranſpiration.

VEGETABLES, being endued with digeſtive organs, throw off all ſuch principles as cannot be aſſimilated by them; and when the functions of the vegetable are not favoured by ſuch cauſes as facilitate them, the nutritive juices are rejected nearly unaltered. We ſhall here attend to three principal ſubſtances that exhale from vegetables, viz. air, water, and aroma.

ARTICLE I.

Concerning Oxigenous Gas afforded by Vegetables.

Dr. Ingenhouſz publiſhed, in the year 1779, Experiments upon Vegetables, in which he affirms that plants poſſeſs the property of emitting vital air when acted upon by the direct rays of the ſun; and that they emit a very mephitic air in the ſhade, and during the night.

Doctor Prieſtley made known the ſame reſults at the ſame time, as well as Mr. Senebier of Geneva, who nevertheleſs did not publiſh a work on this ſubject until the year 1782, in which he admits, as a general principle, that plants ſuffer vital air to eſcape in the ſun-ſhine: but he maintains that they do not produce mephitic air in the ſhade; and is of opinion that, if Dr. Ingenhouſz obtained any, it aroſe from a commencement of putrefaction in the plant.

The ſimpleſt proceſs for extracting this gas from vegetables, conſiſts in immerſing them under water, beneath an inverted glaſs veſſel. It is then ſeen, when the ſun acts on the plant, that ſmall bubbles are emitted, which gradually grow larger, ariſe from the fibres of the leaf, and aſcend to the ſurface of the fluid.

All plants do not afford gas with the ſame facility. There are ſome which emit it the moment the ſun acts upon them; ſuch are the leaves of the jacobæa, of lavender, and of ſome aromatic plants. In other plants the emiſſion is ſlower; but in none later than ſeven or eight minutes, provided the ſun's light be ſtrong. The air is almoſt totally furniſhed by the inferior ſurface of the leaves of trees: it is not the ſame with herbs; for theſe afford air from nearly the whole of their ſurface, according to Senebier.

The leaves afford more air when attached to the plant than when gathered; and the quantity is likewiſe greater the freſher and ſounder they are.

Young leaves afford but a ſmall quantity of vital air; thoſe which are full grown afford more, and the more the greener they are. Leaves which are injured, yellow, or red, do not afford it.

Freſh leaves cut in pieces afford air; and the oxigene gas is capable of being emitted without the plant being plunged under water, as is proved from the experiments of Mr. Senebier.

The parenchyma of the leaf appears to be the part which emits the air. The epidermis, the bark, and the white petals, do not afford air; and in general it is only the green parts of plants which afford oxigenous gas. Green fruits afford air, but thoſe which are ripe do not; and the ſame is true of grain.

It is proved that the ſun does not act in the production of this phenomenon as a body which heats. The emiſſion of this gas is determined by the light; and I have even obſerved that a ſtrong light, without the direct action of the ſun's rays, is ſufficient to produce this phenomenon.

It is proved, by the experiments of Mr. Senebier, that an acid diluted in water increaſes the quantity of air which is diſengaged, when the water is not too much acidulated; and in this caſe the acid is decompoſed.

It has been obſerved that the conferva affords much vital air; as well as the green matter which is formed in water, and is ſuppoſed by Ingenhouſz to be a collection of greeniſh inſects.

Pure air is therefore ſeparated from the plant by the action of light; and the excretion is ſtronger accordingly as the light is more vivid. It ſeems that light favours the work of digeſtion in the plant; and that the vital air, which is one of the principles of almoſt all the nutritive juices, more eſpecially of water, is emitted, when it finds no ſubſtance to combine with in the vegetable. Hence it ariſes that plants whoſe vegetation is the moſt vigorous, afford the greateſt quantity of air: and hence likewiſe it is that a ſmall quantity of the acid mixed with the water favours the emiſſion, and increaſes the quantity of oxigenous gas.

By this continual emiſſion of vital air, the Author of nature inceſſantly repairs the loſs which is produced by reſpiration, combuſtion, and the alteration of bodies, which comprehends every kind of fermentation and putrefaction; and in this manner the equilibrium between the conſtituent principles of the atmoſphere is always kept up.

ARTICLE II.

Concerning the Water afforded by Vegetables.

Plants likewiſe emit a conſiderable quantity of water in the form of vapour, through their pores; and this excretion may be eſtimated as the moſt abundant. Hales has calculated that the tranſpiration of an adult plant, ſuch as the helianthus annuus, was in ſummer ſeven times more conſiderable than that of man.

Guettard has obſerved that this excretion is always in proportion to the intenſity of the light, and not of the heat; ſo that it is ſcacely any during the night. The ſame philoſopher has obſerved that the aqueous tranſpiration is more eſpecially made from the upper ſurface of the leaf. The water which exhales from vegetables is not pure, but ſerves as the vehicle of the aroma; and even carries with it a ſmall quantity of extractive matter, which cauſes it to corrupt ſo ſpeedily.

The immediate effect of the aqueous evaporation conſiſts in maintaining a degree of coolneſs in the plant, which prevents its aſſuming the temperature of the atmoſphere.

ARTICLE III.

Concerning the Aroma, or Spiritus Rector.

Each plant has its characteriſtic ſmell. This odorant principle was diſtinguiſhed by Boerhaave by the name of Spiritus Rector, and by the moderns under the name of Aroma.

The aroma appears to be of the nature of gas, from its fineneſs, its inviſibility, &c. The ſlighteſt heat is ſufficient to expel it from plants. Coolneſs condenſes it, and renders it more ſenſible; and on this account the ſmell of plants is much ſtronger in the morning and evening.

This principle is ſo ſubtile, that the continual emiſſion of it from a wood or flower does not diminiſh its weight, even after a very conſiderable time.

The aroma is ſometimes fixed in an extract, ſometimes in an oil, and this laſt combination is the moſt uſual. It even appears to conſtitute the volatile character of the eſſential or volatile oils.

The nature of the aroma appears to vary prodigiouſly; at leaſt if we may judge by the organ of ſmell, which diſtinguiſhes ſeveral ſpecies. There are ſome which have a nauſeous or poiſonous effect on the animal œconomy. Ingenhouſz quotes an inſtance of the death of a young woman occaſioned by the ſmell of lilies, in 1719; and the famous Triller reports the example of a young woman who died in conſequence of the ſmell of violets, while another was ſaved by removing the flowers. Martinus Cromerus exhibits likewiſe an example of a biſhop of Breſlau who died by a ſimilar cauſe.

The mancenille tree, which grows in the Weſt Indies, emits very dangerous vapours. The humour which flows from this tree is ſo unwholeſome, that if it drop on the hand it raiſes a bliſter.

The American plant lobelia longiflora produces a ſuffocating oppreſſion in the breaſt of thoſe who reſpire in its vicinity, according to Jacquin, Hortus Vindobonenſis. The rhus toxicodendron emits ſo dangerous an exhalation, that Ingenhouſz attributes the return of a periodical diſorder, which attacked the family of the curate of Croſſen in Germany, to a bench ſhaded by this tree, under which they had the cuſtom of ſitting. Every one knows the effects of muſk and oriental ſaffron on certain perſons; and the exhalation of the walnut-tree is conſidered as very unwholeſome.

We may here mention the noxious property of thoſe canes or reeds which in this country are uſed to cover roofs and dunghills, &c. Mr. Poitevin ſaw a man who was very ill on account of having handled theſe canes: the parts of generation were prodigiouſly ſwelled. A dog which had ſlept upon the reeds ſuffered in the ſame manner, and was affected in the ſame parts.

The method of extracting the aroma varies according to its volatility and affinities. It is in general ſoluble in water, alcohol, oils, &c. and theſe fluids are ſeverally employed to extract it from plants which afford it.

When water or alcohol are uſed, they are diſtilled by a gentle heat, and the aroma comes over with them. Simple infuſion may be uſed; and in this way the loſs of a portion of the aroma is avoided.

Water charged with aroma is known by the name of the diſtilled water of the ſubſtance made uſe of. The diſtilled water of inodorous or herbaceous plants does not appear to poſſeſs any virtue; and the apothecaries have long ſince decided the queſtion, by ſubſtituting ſpring water in its place. Spirit of wine combined with the ſame principle, is known by the name of the ſpirit or quinteſſence of the vegetable.

When the aroma is very fugacious, ſuch as that of lilies, jaſmine, or tuberoſe, the flowers are put into a tin cucurbit with cotton ſteeped in oil of ben. The cotton and the flowers are diſpoſed in alternate layers; the cucurbit is cloſed, and a gentle heat applied. In this manner the aroma is permanently combined with the oil.

Theſe are the three methods uſed to retain the odorant principle. The art of the perfumer conſiſts in applying them at pleaſure to various ſubſtances.

Perfumes are either dry or liquid. Among the firſt we may place the ſachets, or little perfumed bags, which contain either mixtures of aromatic plants, or aromas in their native ſtate; the perfumed powders, which obtain their ſmell by a few drops of the ſolution of aroma; the paſtilles or comfits which have ſugar for their baſis, &c.

Liquid perfumes moſt commonly conſiſt of aroma diſſolved in water or alcohol; the various liqueurs, or ſcented ſpirituous cordial waters, are nothing elſe but the ſame ſolutions diluted with water, and ſweetened with ſugar.

For example, to make the eau divine, the bark of four citrons is taken, and put into a glaſs alembic, with two pounds of good ſpirit of wine, and two ounces of orange-flower water; after which, diſtillation is performed on the ſand-bath. On the other hand, one pound and a half of ſugar is diſſolved in one pound and a half of water. The two liquors being mixed, become turbid; but, being left to ſtand, the reſult is an agreeable liquor.

To make the cream of roſes, I take equal parts of roſe water, ſpirit of wine à la roſe, and ſyrup of ſugar. I mix theſe three ſubſtances, and colour the mixture with the infuſion of cochineal.

But it muſt be allowed that, in all perfumes which are a little complicated, the noſe is the beſt chemiſt that can be conſulted; and a good noſe is as requiſite and eſſential to a perfumer, as a ſtrong head is to a geometer.

SECTION V.

Concerning the Alterations to which Vegetables are ſubject after they are deprived of Life.

THE ſame principles which maintain life in vegetables and animals, become the ſpeedieſt agents of their deſtruction when dead. Nature ſeems to have entruſted the compoſition, maintenance, and decompoſition of theſe beings to the ſame agents. Air and water are the two principles which maintain the life in living beings; but the moment they are dead they haſten their alteration and diſſolution. The heat itſelf, which aſſiſted and fomented the functions of life, concurs to facilitate the decompoſition. Thus it is that the froſts of Siberia preſerve bodies for ſeveral months; and that in our mountains they are kept for a long time on the ſnow, when it intercepts the carrying them to the place of interment.

We ſhall examine the action of theſe three agents, namely heat, air, and water; and we ſhall endeavour to ſhew the power and effect of each before we ſhall attend to their combined action.

CHAP. I.

Concerning the Action of Heat upon Vegetable Subſtances.

THE diſtillation of plants by a naked fire is nothing but the act of decompoſing them by means of ſimple heat. This proceſs was for a long time the only method of analyſis. The firſt chemiſts of Paris adopted it for the analyſis of near one thouſand four hundred plants: and it was not till the commencement of the preſent century that this labour was diſcontinued; a labour which did not ſeem to advance the ſcience, ſince in this way the cabbage and hemlock afforded the ſame products.

It is clear that an analyſis by the retort ought not to ſhew the principles of vegetation: for, not to mention that heat changes their nature, by becoming a conſtituent part of the principles extracted; theſe principles themſelves become mixed together, and we can never know their order or ſtate while in the living plant. The action of the heat moreover cauſes the vegetable principles to react upon each other, and confounds the whole together. Whence it ariſes that all vegetables afford nearly the ſame principles; namely, water, an oil more or leſs thick, an acid liquor, a concrete ſalt, and a coal or caput mortuum more or leſs abundant.

Hales took notice that the diſtillation of vegetables afforded much air; and was even in poſſeſſion of an apparatus to collect and meaſure it. But in our time the methods of collecting and confining the gaſes are ſimplified; and the hydro-pneumatic apparatus has proved that the ſubſtances are formed of a mixture of carbonic acid, hydrogene, and ſometimes a little nitrogene.

The order in which the ſeveral products are obtained, and the characters they exhibit, lead us to the following obſervations:

1. The water which paſſes firſt is uſually pure, and without ſmell; but when odorant plants are diſtilled, the firſt drops are impregnated with their aroma. Theſe firſt portions of water conſiſt of that which was ſuperabundant, and mpregnated the vegetable tiſſue.

When the water of compoſition, or that which was in combination with the vegetable, begins to riſe, it carries along with it a ſmall quantity of oil, which colours it; and ſome portions of a weak acid, afforded by the mucilage and other principles with which it exiſted in the ſaponaceous ſtate. The phlegm likewiſe very often contains a ſmall quantity of ammoniac: and this alkali appears to be formed in the operation itſelf; for there are few plants which contain it in their natural ſtate.

2. To the phlegm ſucceeds an oily principle, little coloured at firſt; but, in proportion as the diſtillation advances, the oil which riſes is thicker, and more coloured. They are all characterized by a ſmell of burning, and an acrid taſte, that ariſe from the impreſſion of the fire itſelf. Theſe oils are moſt of them reſinous, and the nitric acid eaſily inflames them. They may be rendered more fluid and volatile by repeated diſtillations.

3. In proportion as the oil comes over, there ſometimes diſtils carbonate of ammoniac, which attaches itſelf to the ſides of the veſſels. It is uſually ſoiled with an oil which colours it. This ſalt does not appear to exiſt ready formed in vegetables. Rouelle the younger proved that the plants which afford the moſt of it, ſuch

as the cruciferous plants, do not contain it in their natural ſtate. It is therefore found when its component parts are volatilized and reunited by the diſtillation.

4. All vegetables afford a very great quantity of gas by diſtillation; and their nature has an influence on the gaſeous ſubſtances they afford. Thoſe plants which abound with reſin, afford much more hydrogenous gas; while ſuch as abound with mucilage produce carbonic acid.

The mixture of theſe gaſes forms an air which is heavier than the common inflammable air, on which account it has been found very little adapted to aëroſtatic experiments.

The art of charring wood, or converting it into charcoal, is an operation nearly ſimilar to the diſtillation we have juſt deſcribed. It conſiſts in forming pyramids of wood, or cones truncated at their ſummit. The whole is covered with earth, well beaten, leaving a lower and upper aperture. The maſs is then ſet on fire; and when the whole is well ignited, the combuſtion is ſtopped by cloſing the apertures through which the current of air paſſed. By this means the water, the oil, and all the principles of the vegetable, are diſſipated, except the fibre. The wood in this operation loſes three-fourths of its weight, and one-fourth of its bulk. According to Fontana and Morozzo, it abſorbs air and water as it cools. I am aſſured, from my experiments in the large way, that pit-coal deſulphurated (coaked) acquires twenty-five pounds of water in the quintal by cooling; but the coal of wood did not appear to me to abſorb more than fifteen or twenty. The ſuturbrand of the Icelanders is nothing but wood converted into charcoal by the lava which has ſurrounded it. —See Von Troil's Letters on Iceland.

The charcoal which is the reſidue of all theſe diſtillations, is a ſubſtance which deſerves an attention more particularly becauſe it enters into the compoſition of many bodies, and bears a very great part in their phenomena.

Charcoal is the vegetable fibre very ſlightly changed. It moſt commonly preſerves the form of the vegetable which afforded it. The primitive texture is not only diſtinguiſhable, but ſerves likewiſe to indicate the ſtate and nature of the vegetable which has afforded it. It is ſometimes hard, ſonorous, and brittle; ſometimes light, ſpongy, and friable; and ſome ſubſtances afford it in a ſubtle powder, without conſiſtence. The coal of oils and reſins is of this nature.

Charcoal well made has neither ſmell nor taſte; and it is one of the moſt indecompoſable ſubſtances we are acquainted with.

When dry, it is not changed by diſtillation in cloſe veſſels. But, when moiſt, it affords hydrogenous gas and carbonic acid; which proves the decompoſition of the water, and the combination of one of its principles with the charcoal, while the other is diſſipated. By ſucceſſively moiſtening and diſtilling charcoal, it may be totally deſtroyed.

Charcoal combines with oxigene, and forms the carbonic acid; but this combination does not take place unleſs their action be aſſiſted by heat. The charcoal which burns in a chaffing-diſh exhibits this reſult; and we perceive two very immediate effects in this operation:—1. A diſengagement of heat, afforded by the tranſition of the oxigenous gas to the concrete ſtate. 2. A production of carbonic acid: it is the formation of this acid gas which renders it dangerous to burn charcoal in places where the current of air is not ſufficiently rapid to carry off the carbonic acid as it is formed.

Well-made charcoal does not change by boiling in water. In proceſs of time it gives a ſlight reddiſh tinge to that fluid which ariſes from the ſolution of the coaly reſidue of the oils of the vegetable mixed with the coaly reſidue of the fibre.

If the ſulphuric acid be digeſted upon charcoal, it is decompoſed; and affords carbonic acid, ſulphureous acid, and ſulphur.

The nitric acid, when concentrated, is decompoſed with much greater rapidity; for if it be poured upon very dry powder of charcoal, it ſets it on fire. This inflammation may be facilitated by heating the charcoal or the acid. If the fluid which ariſes in this experiment be collected, it is found to be carbonic acid, nitrous gas, and nitric acid. M. Prouſt has obſerved, that when the acid is poured into the middle of the charcoal, it does not take fire; but that this effect immediately ſucceeds if the acid be ſuffered to flow beneath the coal. It may even be inflamed by throwing it upon the nitric acid ſlightly heated.

If weak nitric acid be digeſted upon charcoal, it diſſolves it, aſſumes a red colour, becomes paſty, and acquires a bitter diſagreeable taſte.

Charcoal, mixed with the ſulphuric and nitric ſalts, decompoſes them; when combined with oxides, it revives the metals. All theſe effects depend on its very great affinity with the oxigene contained in theſe bodies. It is uſed to facilitate the decompoſition of ſalt-petre in ſome caſes, as in the compoſition of gunpowder, the black flux, &c.

Rouelle has obſerved that the fixed alkali diſſolves a good quantity of charcoal by fuſion. The ſame chemiſt has diſcovered that the ſulphur of alkali diſſolves it in the humid as well as the dry way.

Charcoal is likewiſe capable of combining with metals. It combines with iron in its firſt fuſion, and mixes with it likewiſe in the cementation by which ſteel is formed. When combined with iron in a ſmall proportion of the metal, it conſtitutes plumbago. It is likewiſe capable of combining with tin by cementation; to which metal it gives brilliancy and hardneſs, as I find by experiment.

CHAP. II.

Concerning the Action of Water ſingly applied to Vegetables.

WE may conſider the action of water upon vegetables in two very different points of view. Either the chemiſt applies this fluid to the plant itſelf, to extract and ſeparate the juices from the ligneous part: or elſe the plant itſelf, being immerſed in this fluid, is from this time delivered to its ſingle action; and in that ſituation becomes gradually changed and decompoſed in a peculiar manner. In theſe two caſes, the products of the operations are very different. In the firſt, the ligneous texture remains untouched, and the juices which are ſeparated remain unchanged in the fluid: in the ſecond, more eſpecially when vegetables ferment in heaps, the nature of the juices is partly changed, but the oils and reſins remain confounded with the ligneous tiſſue; ſo that the reſult is a maſs in which the diſorganized vegetable is ſeen in a ſtate of mixture and confuſion of the various principles which compoſe it.

The chemiſt applies water to vegetables, to extract their juices, according to two methods, which conſtitute infuſion and decoction.

Infuſion is performed by pouring upon a vegetable a ſufficient quantity of hot water to diſſolve all its principles. The temperature of the water muſt be varied according to the nature of the plant. If its texture be delicate, or the aroma very fugacious, the water muſt be ſlightly heated; but boiling water may be uſed when the texture is hard and ſolid, and more eſpecially when the plant has no ſmell.

Decoction, which conſiſts in boiling water with the vegetable, ought not to be employed but with hard and inodorous plants. This method is rejected by many chemiſts; becauſe they affirm that, by thus tormenting the plant, a conſiderable quantity of fibrous matter becomes mixed with the juices. Decoction is generally baniſhed from the treatment of odorant plants, becauſe it diſſipates the volatile oil and aroma. The decoction uſed in our kitchens to prepare leguminous plants for food, has the inconvenience of extracting all the nutritive parts, and leaving only the fibrous parenchyma. Hence ariſes the advantage of the American pot or boiler, in which the garden-ſtuff is boiled by ſimple vapour, and conſequently the nutritive principle remains in the vegetable; to which advantage we may add that of uſing any water whatever, becauſe the ſteam alone is applied to the intended purpoſe.

But the infuſion, decoction, and clarification of juices is not left to the choice of the chemiſt when it is required to prepare any medicine; for theſe methods produce ſurpriſing varieties in the virtue of remedies. Thus, for example, according to Storck, the concentrated juice of hemlock has no good qualities unleſs it be evaporated without being clarified.

In treating juniper berries by infuſion, and evaporation on a water bath to the conſiſtence of honey, an aromatic extract is obtained, of a ſaccharine colour: the decoction of the ſame berries affords a leſs fragrant and leſs reſinous extract, becauſe the reſin ſeparates from the oil, and falls down.

The extract of grapes, which is called *reſiné* in France, and moſt ſweetmeats, are prepared in this way.

Extracts are prepared in the large way for ſale by the aſſiſtance of water. We ſhall confine ourſelves to ſpeak of two only, the juice of liquorice and of cachou. The firſt will afford an example of decoction, and the ſecond of infuſion.

The extract of liquorice is prepared in Spain by decoction of the ſhrub of the ſame name. This plant grows abundantly near our ponds; and we might at a ſmall expence avail ourſelves of this ſpecies of induſtry: I have aſcertained that a pound of this root affords two or three ounces of good extract. The apothecaries afterwards prepare it in various ways for their ſeveral purpoſes, and to render its uſe more convenient and agreeable.

The cachou is extracted in the Eaſt Indies from an infuſion of the ſeeds of a kind of palm. While the ſeed is yet green, it is cut, infuſed in hot water; and this infuſion is evaporated to the conſiſtence of an extract, which is afterwards made into lumps, and dried in the ſun. M. de Juſſieu communicated to the Academy, in the year 1720, remarks by which he aſcertains that the differences in the ſeveral kinds of cachou ariſe from the various degrees of maturity in the ſeeds, and the greater or leſs quickneſs with which the extract is dried.

The cachou of commerce is uſually impure; but it may be cleared of its impurities by diſſolving, filtering, and evaporating it ſeveral times.

The taſte of cachou is bitter and aſtringent. It diſſolves very well in the mouth, and is uſed as a reſtorative for weak ſtomachs: it is made into comfits by the addition of three parts of ſugar, and a ſufficient quantity of gum adragant.

When vegetables are immerſed in water, their texture becomes relaxed; all the ſoluble principles are carried off; and there remains only the fibrous part diſorganized, and impregnated with vegetable oil, altered and hardened by the reaction of other principles. This tranſition may be very well obſerved in marſhes, where plants grow and periſh in great numbers, forming mud by their decompoſition. Theſe ſtrata of decompoſed vegetables, when taken out of the water and dried, may be uſed as the material of combuſtion. The ſmell is unwholeſome; but in ſhops, or places where the chimneys draw well, this combuſtible may be uſed.

Vegetables have been conſidered as the cauſe of the formation of pit-coal; but a few foreſts being buried in the earth, are not ſufficient to form the mountains of coal which exiſt in its bowels. A greater cauſe, more proportioned to the magnitude of the effect, is required; and we find it only in that prodigious quantity of vegetables which grows in the ſeas, and is ſtill increaſed by the immenſe maſs of thoſe which are carried down by rivers. Theſe vegetables, carried away by the currents, are agitated, heaped together, and broken by the waves; and afterwards become covered with ſtrata of argillaceous or calcareous earth, and are decompoſed. It is eaſier to conceive how theſe maſſes of vegetables may form ſtrata of coal, than that the remains of ſhells ſhould form the greater part of the globe.

The direct proofs which may be given of the truth of this theory are—

1. The preſence of vegetables in coal mines. The bamboo and banana trees are found in the coal of Alais. It is common to find terreſtrial vegetables confounded with marine plants.

2. The prints of ſhells and of fiſh are likewiſe found in the ſtrata of coal, and not unfrequently ſhells themſelves. The pit-coal of Orſan and that of Saint-Eſprit contain a prodigious number.

3. It is evidently ſeen, by the nature of the mountains which contain charcoal, that their formation has been ſubmarine; for they all conſiſt either of ſchiſtus, or grit, or lime-ſtone. The ſecondary ſchiſtus is a kind of coal in which the earthy principle predominates over the bituminous. Sometimes even this ſchiſtus is combuſtible, as is ſeen in that of St. George near Milhaud. The texture of the vegetables, and the impreſſion of fiſh, are very well preſerved in the ſchiſtus. The origin of the ſchiſtus is therefore ſubmarine; and conſequently ſo likewiſe muſt be the origin of the coal diſtributed in ſtrata through its thickneſs.

The grit-ſtone conſiſts of ſand heaped together, carried into the ſea by the rivers, and thrown up againſt the ſhores by the waves.

The ſtrata of bitumen which are found in theſe cannot therefore but come from the ſea.

Calcareous earth rarely contains ſtrata of coal, but is merely impregnated with it, as at St. Ambroiſe, at Servas, &c. where the bitumen forms a cement with the calcareous earth.

Concerning Pit-Coal.

Pit-coal is uſually found in ſtrata in the earth, almoſt always in mountains of ſchiſtus or grit. It is the property of coal to burn with flame, and the emiſſion of much ſmoke.

The ſecondary ſchiſtus is the baſis of all pit-coal, and the quality of the coal moſtly depends upon the proportion of this baſis. When the ſchiſtus predominates, the coal is heavy, and leaves a very abundant earthy reſidue after its combuſtion. This kind of coal is veined internally with flat pieces, or rather ſeparate maſſes, of ſchiſtus nearly pure, which we call *fiches*.

As the formation of the pyrites, as well as that of coal, ariſes from the decompoſition of vegetable and animal ſubſtances, all pit-coal is more or leſs pyritous; ſo that we may conſider pit-coal as a mixture of pyrites, ſchiſtus, and bitumen. The different qualities of coal ariſe therefore from the difference in the proportions of theſe principles.

When the pyrites is very abundant, the coal exhibits yellow veins of the mineral, which are decompoſed as ſoon as they come in contact with the air; and form on efflореſcence of ſulphate of magneſia, of iron, of alumine, &c.

When pyritous coal is ſet on fire, it emits an inſupportable ſmell of ſulphur; but when the combuſtion is inſenſible, inflammation is frequently produced by the decompoſition of the pyrites; and it is this which occaſions the inflammation of ſeveral veins of coal. There are veins of coal on fire at St. Etienne in Forez, at Cramſac in Rouergue, at Roquecremade in the dioceſe of Beziers; and it is not rare to ſee the fire deſtroy conſiderable maſſes of pyritous coal, when the decompoſition is favoured by the concurrence of air and water. If the inflammation be excited in more conſiderable maſſes of bitumen, the effects are then more ſtriking; and it is to a cauſe of this nature that we ought to refer the origin and effect of volcanos.

When the ſchiſtus, or ſlaty principle, predominates in coals, they are then of a bad quality, becauſe their earthy reſidue is more conſiderable.

The beſt coal is that in which the bituminous principle is the moſt abundant, and exempt from all impurity. This coal ſwells up when it burns, and the fragments adhere together: it is more particularly upon this quality that the practice of the operation called deſulphurating or purifying of coal depends. This operation is analogous to that in which wood is converted into charcoal. In the deſulphuration, pyramids are made, which are ſet on fire at the centre. When the heat has ſtrongly penetrated the maſs, and the flame iſſues out of the ſides, it is then covered with moiſt earth: the combuſtion is ſuffocated, the bitumen is diſſipated in ſmoke, and there remains only a light ſpongy coal, which attracts the air and humidity, and exhibits the ſame phenomena in its combuſtion as the coal of wood. When it is well made, it gives neither flame nor ſmoke; but it produces a ſtronger heat than that of an equal maſs of native coal. This operation received the name of deſulphurating (deſoufrage) from a notion that the coal was by this means deprived of its ſulphur; but it has been proved that all coals which are capable of this operation contain ſcarcely any ſulphur.

It was for a long time ſuppoſed that the ſmell of pit-coal was unwholeſome; but the contrary is now proved. Mr. Venel has made many experiments on this ſubject, and is convinced that neither man nor animals are incommoded by this vapour. Mr. Hoffman relates that diſorders of the lungs are unknown in the villages of Germany where this combuſtible only is uſed. I think that coal of a good quality does not emit any dangerous vapour; but when it is pyritous its ſmell cannot but be hurtful.

The uſe of coal is generally applicable to the arts; and nature appears to have concealed theſe magazines of combuſtible matter, to give us time to repair our exhauſted foreſts. Theſe mines are very abundant and numerous in the kingdom of France. Our province contains many, and we have more than twenty which are in full work. Pit-coal is applied in England even to domeſtic uſes, and this part of mineralogy is very much cultivated in that kingdom. Individuals have there undertaken the moſt conſiderable enterpriſes in this way. The Duke of Bridgwater has made a canal, at Bridgwater, two thouſand five hundred toiſes in length, to facilitate the working of the coal mines in Lancaſhire. It coſt five millions of livres: part of it is carried under a mountain; and it paſſes ſucceſſively under as well as over rivers and highways. In our province we are in want of roads only for the tranſportation of our coal; and Languedoc has not had the ſpirit to perform a work which a private individual has executed in England.

In Scotland, Lord Dundonald has erected

furnaces in which the bitumen is diſengaged from coal; and the vapours are received and condenſed in chambers, over which he has cauſed a river to flow for the purpoſe of cooling them. Theſe condenſed vapours ſupply the Engliſh navy with as much tar as it requires. Becher, in his work intitled "Fooliſh Wiſdom, or Wiſe Folly," printed at Franckfort in 1683, affirms that he ſucceeded in appropriating the bad turf of Holland, and the bad coal of England, to the common uſes. He adds that he obtained tar ſuperior to that of Sweden by a proceſs ſimilar to that of the Swedes. He affirms that he had made this known in England, and ſhewn it to the king.

Mr. Faujas has carried the proceſs of the Scotch nobleman into execution at Paris. The whole conſiſts in ſetting fire to the coal, and extinguiſhing it at the proper time, that the vapour may paſs into chambers containing water for the purpoſe of condenſing them. This tar appeared to be ſuperior to that of wood.

Pit-coal likewiſe affords ammoniac by diſtillation, which is diſſolved in water, while the oil floats above.

When coal is deprived by combuſtion of all the oil and other volatile principles, the earthy reſidue contains the ſulphates of alumine, iron, magneſia, lime, &c. Theſe ſalts are all formed when the combuſtion is ſlow; but when it is rapid the ſulphur is diſſipated, and there remain only the aluminous, magneſian, calcareous, and other earths. The alumine moſt commonly predominates.

Naptha, petroleum, mineral pitch, and aſphaltes, are only ſlight modifications of the bituminous oil ſo abundant in pit-coal. This oil, which the ſimple heat of the decompoſition of the pyrites is ſufficient to diſengage from the coal, receives other modifications by the impreſſion of the external air.

Petroleum, or the oil petrol, is the firſt alteration. This oil is found near volcanos, in the vicinity of coal mines, &c. We are acquainted with ſeveral ſprings of this petroleum. There is one at Gabian in the dioceſe of Beziers. It is carried out by the water of a ſpring which iſſues from the lower part of a mountain whoſe ſummit is volcanized.

The ſmell of petroleum is diſagreeable: its colour is reddiſh; but it may be rendered clear by diſtilling it from the clay of Murviel.

Naptha is merely a variety of petroleum.

Near Derbens, on the Caſpian Sea, there are ſprings of naptha, which Kempfer viſited about a century ago, and of which he has left a deſcription.

There is a place known by the name of the Perpetual Fire, where the fire burns without ceaſing. The Indians do not attribute the origin of this inextinguiſhable fire to naptha; but they maintain that God has confined the Devil in this place, to deliver man from him. They go in pilgrimage thither, and make their prayers to God that he will not ſuffer this enemy of mankind to eſcape.

The earth impregnated with naptha is calcareous, and effervefces with acids; it takes fire by the contact of any ignited body whatever.

This perpetual fire is of great uſe to the inhabitants of Baku. They pare off the ſurface of this burning ſoil, upon which they make a heap of limeſtones, and cover it with the earth pared off; and in two or three days the lime is made.

The inhabitants of the village of Frogann repair to this place to cook their proviſions.

The Indians aſſemble from all parts to adore the Eternal Being in this place. Several temples were built, one of which is ſtill in exiſtence. Near the altar there is a tube inſerted in the earth, two or three feet in length; out of which iſſues a blue flame, mixed with red. The Indians proſtrate themſelves before this tube, and put themſelves into attitudes which are exceedingly ſtrange and painful.

Mr. Gmelin obſerves that two kinds of naptha are diſtinguiſhed in this country; the one tranſparent and yellow, which is found in a well. This well is covered with ſtones ſmeared with a cement of fat earth, in which the name of Kan is engraved; and no one is permitted to break this ſealed covering but thoſe who are deputed from the Kan.

Mineral pitch is likewiſe a modification of petroleum. It is found in Auvergne, at a place called Puits de Lapege, near Alais, in an extent of ſeveral leagues, which comprehends Servas, Saint Ambroiſe, &c.

The calcareous ſtone is impregnated with a bitumen which is ſoftened by the heat of ſummer, when it flows from the rocks, and forms a very beautiful ſtalactites. It forms maſſes in the fields, and impedes the paſſage of carriages: the peaſants uſe it to mark their ſheep. This ſtone emits an abominable ſmell when rubbed. The epiſcopal palace of Alais was paved with it in the time of Mr. Davejan; but it became neceſſary to ſubſtitute other ſtone in its ſtead. It is aſſerted that mineral pitch was uſed to cement the walls of Babylon.

Aſphaltes, or bitumen Judaicum, is black, brilliant, ponderous, and very brittle.

It emits a ſmell by friction; and is found floating on the water of the lake Aſphaltites, or the Dead Sea.

The aſphaltes of commerce is extracted from the mines of Annemore, and more particularly in the principality of Neufchatel. Mr. Pallas found ſprings of aſphaltes on the banks of the Sock, in Pruſſia.

Moſt naturaliſts conſider it as amber decompoſed by fire.

Aſphaltes liquefies on the fire, ſwells up, and affords flame, with an acrid diſagreeable ſmoke.

By diſtillation it affords an oil reſembling petroleum. The Indians and Arabs uſe it inſtead of tar, and it is a component part of the varniſh of the Chineſe.

Yellow amber, karabe, or the electram of the ancients, is in yellow or brown pieces, tranſparent or opake, capable of a poliſh, becoming electric by friction, &c.

It is friable and brittle.

There is no ſubſtance on which the imagination of poets has been more exerciſed than this. Sophocles had affirmed that it was formed in India by the tears of the ſiſters of Meleager, changed into birds, and deploring the fate of their brother; but one of the moſt intereſting fabulous origins which have been attributed to it, is afforded by the fable of Phaeton burning the heavens and the earth, and precipitated by the thunder of Jove into the waters of Eridanus. His ſiſters are deſcribed weeping; and the precious tears fell into the waters without mixing with them, became ſolid without loſing their tranſparency, and were converted into the yellow amber ſo highly valued by the ancients. —See Bailly.

Amber poſſeſſes leſs coaly matter than any other bitumen.

It is frequently found diſperſed over ſtrata of pyritous earth, and covered with a ſtratum of wood, abounding with a blackiſh bituminous matter.

It is found floating in the Baltic Sea, on the coaſt of Ducal Pruſſia; it is alſo found near Siſtreron in Provence.

No other chemical uſe was for a long time made of amber, than to form compoſitions for medicine and the arts. We are indebted to Neumann, Bourdelin, and Pott, for a tolerably accurate analyſis of this bitumen. The two conſtituent principles exhibited in the analyſis of amber, are the ſalt of amber or ſuccinic acid, and a bituminous oil.

To extract the ſuccinic acid, the amber is broken into ſmall pieces, which are put into a retort, and diſtilled with a ſuitable apparatus upon a ſand bath. When the fire is carefully managed, the products are—1. An inſipid phlegm. 2. Phlegm holding a ſmall portion of acid in ſolution. 3. A concrete acid ſalt, which attaches itſelf to the neck of the retort. 4. A brown and thick oil, which has an acid ſmell.

The concrete ſalt always retains a portion of oil* in its firſt diſtillation. Scheffer, in his Leſſons of Chemiſtry, propoſes to diſtil it with ſand; Bergmann with white clay; Pott adviſes ſolution in water, and filtration through white cotton; after which the fluid is to be evaporated, and is found to be deprived of the oil, which remains on the cotton. Spielmann, after Pott, propoſes to diſtil it with the muriatic acid; it then ſublimes white and pure. Bourdelin clears it of its oil by detonation with nitre. This ſalt is prepared in the large way at Koningſberg, where the ſhavings and chips of amber are diſtilled.

The ſuccinic acid has a penetrating taſte, and reddens the tincture of turnſole. Twenty-four parts of cold water, and two of boiling water, diſſolve one of this acid. If a ſaturated ſolution of this ſalt be evaporated, it cryſtallizes in triangular priſms, whoſe points are truncated.

M. De Morveau obſerves that its affinities are barytes, lime, alkalis, magneſia, &c.

---

* *Acide* in the original: doubtleſs by overſight. T.

The oil of amber has an agreeable ſmell: it may be deprived of its colour by diſtillation from white clay. Rouelle diſtilled it with water. When mixed with ammoniac it forms a liquid ſoap, known by the name of Eau de Luce.

To make eau de luce, I diſſolve Punic wax in alcohol, with a ſmall quantity of oil of amber; and on this I pour the pure volatile alkali.

Alcohol attacks amber, and acquires a yellow colour. Hoffman prepares this tincture by mixing the ſpirit of wine with an alkali.

The medical uſe of amber conſiſts in burning it, and receiving the vapour on the diſeaſed part. Theſe vapours are ſtrengthening, and remove obſtructions. The oil of amber is applied to the ſame uſe. A ſyrup of amber is made with the ſpirit of amber and opium, which is uſed to advantage as a ſedative anodyne medicine. The fineſt pieces of amber are uſed to make toys. Wallerius affirms that the moſt tranſparent pieces may be uſed to make mirrors, priſms, &c. It is ſaid that the King of Pruſſia has a burning mirror * of amber one foot in diameter; and that there is a column of amber in the cabinet of the Duke of Florence ten feet high, and of a very fine luſtre.

---

* So in the original; but the matter as well as the properties of this ſubſtance put it out of doubt that it ſhould be *lens*. T.

Concerning Volcanos.

The combuſtion of theſe enormous maſſes of bitumen which are depoſited in the bowels of the earth, produces volcanos. They owe their origin more eſpecially to the ſtrata of pyritous coal. The decompoſition of water upon the pyrites determines the heat, and the production of a great quantity of hydrogenous gas, which exerts itſelf againſt the ſurrounding obſtacles, and at length breaks them. This effect is the chief cauſe of earthquakes; but when the concourſe of air facilitates the combuſtion of the bitumen and the hydrogenous gas, the flame is ſeen to iſſue out of the chimneys or vents which are made: and this occaſions the fire of volcanos.

There are many volcanos ſtill in an active ſtate on our globe, independent of thoſe of Italy, which are the moſt known. The abbé Chappe has deſcribed three burning in Siberia, Anderſon and Von Troil have deſcribed thoſe of Iceland. Aſia and Africa contain ſeveral: and we find the remains of theſe fires or volcanic products in all parts of the globe.

Naturaliſts inform us that all the ſouthern iſlands have been volcanized; and they are ſeen daily to be formed by the action of theſe ſubterraneous fires. The traces of fire exiſt even immediately around us. The ſingle province of Languedoc contains more extinct volcanos than twenty years ago were known to exiſt through all Europe. The black colour of the ſtones, their ſpongy texture, the other products of fire, and the identity of theſe ſubſtances with thoſe of the volcanos at preſent burning, are all in favour of the opinion that their origin was the ſame.*

When

---

* A volcano was announced and deſcribed to be burning in Languedoc, reſpecting which it is neceſſary to give ſome elucidation. This pretended volcano is known by the name of the Phoſphorus of Venejan.

Venejan is a village ſituated at the diſtance of a quarter of a league from the high road between St. Eſprit and Bagnols. From time immemorial, at the return of ſpring, a fire was ſeen from the high road, which increaſed during the ſummer, was gradually extinguiſhed in autumn, and was viſible only in the night. Several perſons had at various times directed their courſe from the high road, in a right line towards Venejan, to verify the fact upon the ſpot; but the neceſſity of deſcending into a deep valley before they could arrive thither, occaſioned them to loſe ſight of the fire; and on their arrival at Venejan no appearance was ſeen in the leaſt reſembling the fire of a volcano. Mr. de Genſſane deſcribes this phenomenon, and compares it to the flaſhing of a ſtrong aurora borealis: he even ſays that the country is volcanic. Hiſt. Nat. du Languedoc, Dioceſe D'Uzes.—At length, in the courſe of the laſt four or five years, it was obſerved that theſe fires were multiplied

When the decompoſition of the pyrites is advanced, and the vapours and elaſtic fluids can no longer be contained in the bowels of the earth, the ground is ſhaken, and exhibits the phenomena of earthquakes. Mephitic vapours are multiplied on the ſurface of the ground,

---

multiplied in the ſpring; and that, inſtead of one, there were three. Certain philoſophers of Bagnols undertook the project of examining this phenomenon more cloſely; and for this purpoſe they repaired to a ſpot between the high road and Venejan, armed with torches, ſpeaking trumpets, and every other implement which they conceived to be neceſſary for making their obſervations. At midnight, four or five of the party were deputed and directed towards the fire; and thoſe who remained behind directed them conſtantly in their way by means of their ſpeaking trumpets. They at laſt arrived at the village, where they found three groups of women winding ſilk in the middle of the ſtreet by the light of a fire made of hemp ſtalks. All the volcanic phenomena then diſappeared, and the explanation of the obſervations made on this ſubject became very ſimple. In the ſpring, the fire was weak, becauſe it was fed with wood, which afforded heat and light; during the ſummer, hemp ſtalks were burned, becauſe light only was wanted. At that time there were three fires, becauſe the fair of Saint Eſprit was near at hand, at which they ſold their ſilk, and which conſequently put them under the neceſſity of expediting their work. As theſe obſervers announced their arrival with much noiſe, the country people drove them back by a ſhower of ſtones, which the Don Quixotes of natural hiſtory might have taken for a volcanic eruption.

and dreadful hollow noiſes are heard. In Iceland, the rivers and ſprings are ſwallowed up; a thick ſmoke, mixed with ſparks and lightning, is then diſengaged from the crater; and naturaliſts have obſerved that, when the ſmoke of Veſuvius takes the form of a pine, the eruption is near at hand.

To theſe preludes, which ſhew the internal agitation to be great, and that obſtacles oppoſe the iſſue of the volcanic matters, ſucceeds an eruption of ſtones and other products, which the lava drives before it; and laſtly appears a river of lava, which flows out, and ſpreads itſelf down the ſide of the mountain. At this period the calm is reſtored in the bowels of the earth, and the eruption continues without earthquakes. The violent efforts of the included matter ſometimes cauſe the ſides of the mountain to open; and this is the cauſe which has ſucceſſively formed the ſmaller mountains which ſurround volcanos. Montenuovo, which is a hundred and eighty feet high, and three thouſand in breadth, was formed in a night.

This criſis is ſometimes ſucceeded by an eruption of aſhes which darken the air. Theſe aſhes are the laſt reſult of the alteration of the coals; and the matter which is firſt thrown out is that which the heat has half vitrified. In the year 1767, the aſhes of Veſuvius were carried twenty leagues out to ſea, and the ſtreets of Naples were covered with them. The report of Dion, concerning the eruption of Veſuvius in the reign of Titus, wherein the aſhes were carried into Africa, Egypt, and Syria, ſeems to be fabulous. Mr. de Sauſſure obſerves that the ſoil of Rome is of this character, and that the famous catacombs are all made in the volcanic aſhes.

It muſt be admitted, however, that the force with which all theſe products are thrown, is aſtoniſhing. In the year 1769, a ſtone twelve feet high, and four in circumference was thrown to the diſtance of a quarter of a mile from the crater: and in the year 1771 Sir William Hamilton obſerved ſtones of an enormous ſize, which employed eleven ſeconds in falling.

The eruption of volcanos is frequently aqueous: the water, which is confined, and favours the decompoſition of the pyrites, is ſometimes ſtrongly thrown out. Sea ſalt is found among the ejected matter, and likewiſe ſal ammoniac. In the year 1630, a torrent of boiling water, mixed with lava, deſtroyed Portici and Torre del Greco. Hamilton ſaw boiling water ejected.

ed. The ſprings of boiling water in Iceland, and all the hot ſprings which abound at the ſurface of the globe, owe their heat only to the decompoſition of pyrites.

Some eruptions are of a muddy ſubſtance; and theſe form the tufa, and the puzzolano. The eruption which buried Herculaneum is of this kind. Hamilton found an antique head, whoſe impreſſion was well enough preſerved to anſwer the purpoſe of a mould. Herculaneum, at the leaſt depth, is ſeventy feet under the ſurface of the ground, and often at one hundred and twenty.

The puzzolano is of various colours. It is uſually reddiſh; ſometimes gray, white, or green: it frequently conſiſts of pumice ſtone in powder; but ſometimes it is formed of calcined clay. One hundred parts of red puzzolano afforded Bergmann, ſilex 55, alumine 20, lime 5, iron 20.

When the lava is once thrown out of the crater, it rolls in large rivers down the ſide of the mountain to a certain diſtance, which forms the currents of lava, the volcanic cauſeways, &c. The ſurface of the lava cools and forms a ſolid cruſt, under which the liquid lava flows. After the eruption, this cruſt ſometimes remains, and forms hollow galleries, which Meſſrs. Hamilton and Ferber have viſited: it is in theſe hollow places that the ſal ammoniac, the marine ſalt, and other ſubſtances, ſublime. A lava may be turned out of its courſe by oppoſing banks or dikes againſt it: this was done in 1669, to ſave Catania; and Sir William Hamilton propoſed it to the king of Naples, to preſerve Portici.

The currents of lava ſometimes remain ſeveral years in cooling. Sir William Hamilton obſerved, in 1769, that the lava which flowed in 1766 was ſtill ſmoking in ſome places.

When the current of lava is received by water, its cooling is quicker; and the maſs of lava ſhrinks ſo as to become divided into thoſe columns which are called baſaltes. The famous Giants' Cauſeway is the moſt aſtoniſhing effect of this kind which we are acquainted with. It exhibits thirty thouſand columns in front, and is two leagues in length along the ſea coaſt. Theſe columns are between fifteen and ſixteen inches in diameter, and from twenty-five to thirty feet long.

The baſaltes are divided into columns of four, five, ſix, and ſeven ſides. The emperor Veſpaſian made an entire ſtatue, with ſixteen children, out of a ſingle column of baſaltes, which he dedicated to the Nile, in the Temple of Peace.

Baſaltes afforded Bergmann, per quintal, ſilex 56, alumine 15, lime 4, iron 25.

Lava is ſometimes ſwelled up and porous. The lighteſt is called pumice-ſtone.

The ſubſtances thrown out by volcanos are not altered by fire. They eject native ſubſtances, ſuch as quartz, cryſtals of amethyſt, agate, gypſum, amianthus, feld-ſpar, mica, ſhells, ſchorl, &c.

The fire of volcanos is ſeldom ſtrong enough to vitrify the matters it throws out. We know only of the yellowiſh capillary and flexible glaſs thrown out by the volcanos of the iſland of Bourbon on the fourteenth of May 1766 (M. Commerſon), and the lapis gallinaceus ejected by Hecla. Mr. Egolfrjouſon, who is employed by the Obſervatory at Copenhagen, has ſettled in Iceland, where he uſes a mirror of a teleſcope which he has made out of the black agate of Iceland.

The ſlow operation of time decompoſes lavas, and their remains are very proper for vegetation. The fertile iſland of Sicily has been every where volcanized. I obſerved ſeveral ancient volcanos at preſent cultivated; and the line which ſeparates the other earths from the volcanic earth, conſtitutes the limit of vegetation. The ground over the ruins of Pompeia is highly cultivated. Sir William Hamilton conſiders ſubterranean fires as the great vehicle uſed by nature to extract virgin earth out of the bowels of the globe, and repair the exhauſted ſurface.

The decompoſition of lava is very ſlow. Strata of vegetable earth, and pure lava, are occaſionally found applied one over the other; which denote eruptions made at diſtances of time very remote from each other, ſince it requires nearly two thouſand years before lava receives the plough. An argument has been drawn from this phenomenon to prove the antiquity of the globe: but the ſilence of the moſt ancient authors concerning the volcanos of our kingdom, of which we find ſuch frequent traces, proves that theſe volcanos have been extinguiſhed from time immemorial; a circumſtance which carries their exiſtence to a very diſtant period. Beſides this, ſeveral thouſand years of connected obſervations have not afforded any remarkable change in Veſuvius's or Etna; nevertheleſs, theſe enormous mountains are all volcanized, and conſequently formed of ſtrata applied one upon the other. The prodigy becomes much more ſtriking, when we obſerve that all the ſurrounding country, to very great diſtances, has been thrown out of the bowels of the earth.

The height of Veſuvius above the level of the ſea is three thouſand ſix hundred and fifty-nine feet; its circumference thirty-four thouſand four hundred and forty-four. The height of Etna is ten thouſand and thirty-ſix feet; and its circumference one hundred and eighty thouſand.

The various volcanic products are applicable to ſeveral uſes.

1. The puzzolano is of admirable uſe for building in the water: when mixed with lime, it ſpeedily fixes itſelf; and water does not ſoften it, for it becomes continually harder and harder. I have proved that calcined ochres afford the ſame advantage for this purpoſe; they are made into balls, and baked in a potter's furnace in the uſual manner. The experiments made at Sette, by the commiſſary of the province, prove that they may be ſubſtituted with the greateſt advantage, inſtead of the puzzolano of Italy.

2. Lava is likewiſe ſuſceptible of vitrification; and in this ſtate it may be blown into opake bottles of the greateſt lightneſs, as I have done at Erepian and at Alais. The very

hard lava, mixed in equal parts with wood aſhes and ſoda, produced an excellent green glaſs. The bottles made of it were only half the weight of common bottles, and much ſtronger; as was proved by my experiments, and thoſe which Mr. Joly de Fleury ordered to be made under his adminiſtration.

3. Pumice ſtone likewiſe has its uſes; it is more eſpecially uſed to poliſh moſt bodies which are ſomewhat hard. It is employed in the maſs or in powder, according to the intended purpoſe. Sometimes, after levigation, it is mixed with water to render it ſofter.

CHAP. III.

Concerning the Decompoſition of Vegetables in the Bowels of the Earth.

HERBACEOUS plants, buried in the earth, are ſlowly decompoſed; but the waters which filter through and penetrate them relax their texture. The ſalts are extracted; and they become converted into a ſtratum of blackiſh matter, in which the vegetable texture is ſtill diſcernible. Theſe ſtrata are ſometimes perceived in digging into the earth. But this alteration is infinitely more perceptible in wood itſelf, than in herbaceous plants. The ligneous body of a tree buried under the ground becomes of a black colour, more friable, and breaks ſhort; the fracture is ſhining; and the whole maſs appears, in this ſtate, to form an uniform ſubſtance, capable of the fineſt poliſh. The wood thus changed is called Jet. In the environs of Montpellier, near St. Jean de Cucule, ſeveral cart loads of trunks of trees have been dug up, whoſe form was perfectly preſerved, but which were converted into jet. I have myſelf found a wooden peal converted into jet. In the works at Niſmes pieces of wood were found entirely converted into the ſtate of jet. In the neighbourhood of Vachery, in Gevaudan, a jet is found, in which the texture of the walnut-tree is very diſcernible. The texture of the beech is ſeen in the jet of Boſrup in Scania. In Guelbre a foreſt of pines has been diſcovered buried beneath the ſand; and at Beichlitz two ſtrata of coal are wrought, according to Mr. Jars, the one bituminous, and the other of foſſil wood. I preſerve in the cabinet of mineralogy of Languedoc, ſeveral pieces of wood, whoſe external part is in the ſtate of jet, while the internal part ſtill remains in the ligneous ſtate; ſo that the tranſition from the one to the other may be obſerved.

Jet is capable of receiving the moſt perfect poliſh. It is made into toys, ſuch as buttons, ſnuff-boxes, necklaces, and other ornaments. It is wrought in Languedoc, near Saint Colombe, at the diſtance of three leagues from Caſtelnaudray. It is ground down, and cut into facets, by mills.

Jet ſoftens in the fire, and burns with the emiſſion of a fetid odour. It affords an oil which is more or leſs black, but may be rendered colourleſs by repeated diſtillations from the earth of Murviel.

CHAP. IV.

Concerning the Action of Air and Heat upon Vegetables.

WHEN heat is applied to a vegetable expoſed to the air, certain phenomena are produced, which depend on the combination of pure air, with the inflammable principles of the plant; and this is combuſtion.

In order to produce a commencement, a heated body is applied to the dry wood which is intended to be ſet on fire. By this means the principles are volatilized in the ſame order as we have pointed out in the preceding article. A ſmoke is produced, which is a mixture of water, oil, volatile ſalts, and all the gaſeous products which reſult from the combination of vital air with the ſeveral principles of the vegetable. The heat then increaſes by the combination of the air itſelf, becauſe it paſſes to the concrete ſtate; and when this heat is carried to a certain point, the vegetable takes fire, and the combuſtion proceeds until all the inflammable principles are deſtroyed.

In this operation there is an abſorption of vital air, and a production of heat and light. The combuſtion will be ſtronger in proportion as the inflammable principle is more abundant, as the aqueous principle is leſs abundant, as the wood is more reſinous, and as the air is purer and more condenſed.

The diſengagement of heat and light is more conſiderable, accordingly as the combination of vital air is ſtronger in a given time.

The reſidues of combuſtion conſiſt of ſubſtances which are volatilized, and fixed ſubſtances; the one forms the ſoot, the other the aſhes.

The ſoot partly ariſes from ſubſtances imperfectly burned, decompoſed only in part, which have eſcaped the action of vital air. Hence it is that the ſoot may be burned over again: and hence likewiſe it is that, when the combuſtion is very rapid and effectual, there is no perceptible ſmoke; becauſe all the inflammable matter is then deſtroyed, as in the cylinder lamps, violent fires, &c.

The analyſis of ſoot exhibits an oil which may be extracted by diſtillation; a reſin which may be taken up by alcohol, and which ariſes either from the imperfect alteration of the reſin of the vegetable, or the combination of vital air with the volatile oil. It likewiſe affords an acid, which is often formed by the decompoſition of mucus; and it is this acid, of great utility in the arts, for which the Academy of Stockholm has deſcribed a furnace proper for collecting it. Soot likewiſe affords volatile ſalts, ſuch as the carbonate of ammoniac, and others. A ſlight portion of fibrous matter is likewiſe volatilized by the force of the fire, and we find it again in the ſoot.

The fixed principle remaining after combuſtion,

tion, forms the aſhes. They contain ſalts, earths, and metals, of which we have already treated. The ſalts are fixed alkalis, ſulphates, nitrates, muriates, &c. the metals are iron, gold, manganeſe, &c. and the earths are alumine, lime, ſilex, and magneſia.

CHAP. V.

Concerning the Action of Air and Water, which determine a Commencement of Fermentation that ſeparates the Vegetable Juices from the Ligneous Part.

WHEN the decompoſition of vegetables is facilitated by the alternate action of air and water, their organization becomes deſtroyed; the connection between the various principles is broken; the water carries away the juices, and leaves the fibrous ſkeleton naked, ſufficiently coherent, and ſufficiently abundant in certain vegetables, to be extracted in this way. Hemp is prepared in this manner. The abbé Rozier attributes the advantage of watering to the fermentation of the mucilaginous part. M. Prozet has proved that hemp contains an extractive and a reſinous part; and that the watering deſtroys the former, and the ſecond is detached almoſt mechanically, It has been obſerved that the addition of a ſmall quantity of alkali favours this operation.

Running water is preferable to ſtanding water; becauſe ſtanding water keeps up a developes a ſtronger fermentation, which attacks the ligneous part. It has been obſerved that flax prepared in running water is whiter and ſtronger than that which is prepared in ſtanding water. The ſtagnant water has likewiſe the inconvenience of emitting an unpleaſant ſmell, pernicious to the animal œconomy. The addition of alkali corrects and prevents this effect.

In the dioceſe of Lodeve, the young ſhoots of the Spaniſh genet are prepared by a very ſimple proceſs. It is ſown on the high grounds, where it is left for three years; at the end of which time the ſprigs or young ſhoots are cut, and formed into bundles, which are ſold from twelve to fifteen ſous each. The firſt operation conſiſts in cruſhing them with a beetle. The following day they are laid in a running ſtream, with ſtones upon them, to prevent their being waſhed away. In the evening they are taken out, and laid in a heap on the banks of the river, upon ſtraw or fern, covering them with the ſame, and loading the heap with ſtones: this operation they call *mettre à couvert*. Every evening they throw water on the heap. At the end of eight days they open the maſs, and find that the bark is eaſily ſeparated from the wood. They take the packets, one after the other, and beat and rub them ſtrongly with a flat ſtone, till the epidermis of the extremities is well cleared off, and the whole ſtem becomes white. It is then hung to dry; and the bark which was ſeparated from the ligneous ſubſtance, is carded and ſpun, and made into very uſeful cloth. The peaſants are acquainted with no other linen for cloths, ſacks, ſhirts, &c. Every one prepares his own, none being made for ſale.

The genet, geniſta juncea, has likewiſe the advantage of affording a green food to cattle during the winter; at the ſame time that it ſupports the earth by its roots, and prevents its being carried down into the valleys. The bark of the mulberry tree may be treated in the ſame manner. Olive de Serres has deſcribed a good proceſs for this purpoſe.

It is the ſkeleton formed by the vegetable fibre only, and deprived of all foreign matter, which is uſed to make cloth; it is the moſt incorruptible principle of vegetation: and when this fibre, being converted into cloth, can no longer be uſed as ſuch, it is ſubjected to extreme diviſion, to convert it into paper. The operations for this purpoſe are the following: —The rags are cleaned, and laid in water to rot; after which they are torn by hooked peſtles moved by water: the ſecond peſtles under which they are made to paſs, are not armed with hooks like the firſt, but merely with round nails: the third are of wood only. By this means the rags are converted into a paſte, which is attenuated ſtill more by boiling. This paſte is received in wire moulds, dried, and forms blotting paper. Writing paper is dipped in ſize, and ſometimes glazed.

CHAP. VI.

Concerning the Action of Air, of Heat, and of Water upon Vegetables.

WHEN the various juices of vegetables are diffuſed in water, and the action of this fluid is favoured by the combined action of air and heat, a decompoſition of theſe juices enſues. The oxigenous gas may be conſidered as the firſt agent of fermentation: it is afforded either by the atmoſphere, or by the water which is decompoſed.

It was from an obſervation of theſe facts that Becher thought himſelf authorized to conſider fermentation as a kind of combuſtion:—"Nam combuſtio, ſeu calcinatio per fortem ignem, licet putrefactionis ſpecies, eidemque analoga ſit—fermentatio ergo definitur, quod ſit corporis denſioris rarefactio, particularumque aërearum interpoſitio, ex quo concluditur debere in aëre fieri, nec nimium frigido nec nimium calido, ne partes raribiles expellantur, in aperto tamen vaſe, vel tantum vacuo ut partes rarefieri queant; nam ſtricta cloſura, et vaſis impletio, fermentationem totaliter impedit."—Becher, Phyſ. Subſt. ſ. i. 15, v. cap. 11, p. 313.

The conditions neceſſary for the eſtabliſhment of fermentation are—1. The contact of pure air. 2. A certain degree of heat. 3. A quantity of water more or leſs conſiderable, which produces a difference in the effects.

The phenomena which eſſentially accompany fermentation are—1. The production of heat. 2. The abſorption of oxigenous gas.

Fermentation may be aſſiſted—1. By increaſing the maſs of fermentable matter. 2. By uſing a proper leaven.

1. By increaſing the fermentable maſs, the principles on which the air muſt act are multiplied; conſequently the action of this element is facilitated; more heat is therefore produced by the fixation of a greater quantity of air; and conſequently the fermentation is promoted by the two cauſes which moſt eminently maintain it, heat and air.

2. Two kinds of leaven may be diſtinguiſhed. 1. Bodies eminently putreſcible, the addition of which haſtens the fermentation. 2. Thoſe which already abound with oxigene, and which conſequently afford a greater quantity of this principle of fermentation. This effect is produced by the inhabitants of the banks of the Rhyn, by throwing freſh meat into the vintage, to haſten the ſpirituous fermentation (Linné Amœnit. Acad. Diſſert. de Geneſi Calculi): and ſo likewiſe the Chineſe throw excrements into a kind of beer, made of a decoction of barley and oats. And on this account it is that the acids, the neutral ſalts, chalk, rancid oils, and the metallic calces, &c. haſten fermentation.

The products of fermentation have cauſed different ſpecies to be diſtinguiſhed: but this variety of effects depends on the variety of principles in the vegetable. When the ſaccharine principle predominates, the reſult of the fermentation is a ſpirituous liquor; when, on the contrary, the mucilage is moſt abundant, the product is acid; if the gluten be one of the principles of the vegetable, there will be a production of ammoniac in the fermentation: ſo that the ſame fermentable maſs may undergo different alterations, which always depend on the nature and reſpective properties of the conſtituent principles, the ſuſceptibility of change, &c. Thus a ſaccharine liquid, after having undergone the ſpirituous fermentation, may be ſubjected to the acid fermentation, by the decompoſition of the mucilage which had reſiſted the firſt fermentation: but in all caſes the concourſe of air, water, and heat, is neceſſary to develop fermentation. We ſhall therefore confine ourſelves to the examination of theſe three agents: 1. On the juices extracted from vegetables, and diffuſed in water, which conſtitutes the ſpirituous and acid fermentations: 2. On the vegetable itſelf, which will lead us to the formation of vegetable mould, ochres, &c.

ARTICLE I.

Concerning the Spirituous Fermentation and its Products.

That fermentation is diſtinguiſhed by the name of Spirituous, which affords ardent ſpirit, or alcohol, as its product or reſult.

It may be conſidered as a fundamental principle, that no ſubſtances are capable of this fermentation but ſaccharine bodies. Pure ſugar mixed with water forms taffia, or rum, by fermentation, and we find this principle in the analyſis of all the bodies which are ſuſceptible of it.

In order to develop this fermentation, there is required, 1. The acceſs of air. 2. A degree of heat between ten and fifteen of Reaumur. 3. The diviſion and expreſſion of the juice contained in the fruits, or in the plant. 4. A maſs or volume ſomewhat conſiderable.

We will make the application of theſe principles to the fermentation of grapes. When theſe are ripe, and the ſaccharine principle is developed, they are then preſſed, and the juice which flows out is received in veſſels of a proper capacity, in which the fermentation appears, and proceeds in the following manner:—

At the end of ſeveral days, and frequently after a few hours, according to the heat of the atmoſphere, the nature of the grapes, the quantity of the liquid, and the temperature of the place in which the operation is performed, a movement is produced in the liquor, which continually increaſes; the volume of the fluid increaſes; it becomes turbid and oily; carbonic acid is diſengaged, which fills all the unoccupied part of the veſſel, and the temperature riſes to the 18th degree. At the end of ſeveral days theſe tumultuous motions ſubſide, the maſs falls, the liquor becomes clearer, and is found to be leſs ſaccharine, more odorant, and of a red colour, from the reaction of the ardent ſpirit upon the colouring matter of the pellicle of the grape *.

The cauſes of an imperfect fermentation are the following: 1. If the heat be too little, the fermentation languiſhes, the ſaccharine and oily matters are not ſufficiently elaborated, and the wine is unctuous and ſweet.

2. If the ſaccharine body be not ſufficiently abundant,

---

* Richardſon, in his Treatiſe on Brewing. inſiſts much on the difference between the ſpecific gravity of the fluid before and after fermentation. which he conſiders as proportional to the ſtrength or inebriating quality of the fluid. Fermented liquors have a leſs ſpecific gravity than they poſſeſſed before the fermentation. This circumſtance well deſerves the attention of the manufacturer. T.

abundant, as happens in rainy ſeaſons, the wine is weak, and the mucilage which predominates cauſes it to become ſour by its decompoſition.

3. If the juice be too watery, concentrated and boiling muſt is added.

4. If the ſaccharine principle be not ſufficiently abundant, the defect may be remedied by the addition of ſugar. Macquer has proved that excellent wine may be made of verjuice and ſugar; and Mr. De Bullion has made wine at Bellejames with the verjuice of his vine rows and moiſt ſugar.

There have been many diſputes to determine whether grapes ſhould be preſſed with the ſtalks or without. It ſeems to me that this depends on the nature of the fruit. When they are highly charged with ſaccharine and mucilaginous matter, the ſtalk corrects the inſipidity of the wine by its bitter principle: but when, on the contrary, the juice is not too ſweet, the ſtalk renders it drier, and very rough.

The wine is uſually taken out of the fermenting veſſels at the period when all the phenomena of fermentation have ſubſided. When the maſs is ſettled, the colour of the liquor is well developed, when it has become clear, and its heat has diſappeared; it is put into caſks, where, by a ſecond inſenſible fermentation, the wine is clarified, its principles combine more perfectly together, and its taſte and ſmell become more and more developed.

If this fermentation be ſtopped or ſuffocated, the gaſeous principles are retained, and the wine is briſker, and more of the nature of muſt. Becher had very proper ideas of the effects of theſe two fermentations.

Diſtinguitur autem inter fermentationem apertam et clauſam: in aperta potus fermentatus ſanior eſt, ſed debilior; in clauſa non ita ſanus, ſed fortior: cauſa eſt quod evaporantia rarefacta corpuſcula imprimis magna adhuc ſilveſtrium ſpirituum copia, de quibus antea egimus, retineatur, et in ipſum potum ſe precipitet, unde valde eum fortem reddit. Becher, Phyſ. Subt. lib. 1, v. V. cap. 11, p. 313.

It appears, from the intereſting experiments of the Marq. de Bullion, that the vinous fermentation does not take place unleſs tartar be preſent.

By evaporating the muſt of grapes, a ſalt is obtained, which has the appearance of tartar, and forms ſalt of Seignette with the alkali of ſoda. A large quantity of ſugar is alſo obtained. For this purpoſe the tartar is firſt to be extracted; after which, the muſt having evaporated to the conſiſtence of a thick ſyrup, is to be left for ſix months in a cellar. At the expiration of this time, the ſugar is found in a confuſed ſtate of cryſtallization; and this being waſhed with ſpirit of wine, to carry off the colouring part, becomes very fine and pure.

Wine deprived of its tartar ferments no more, and the fermentation is in proportion to the abundance of the tartar. Cream of tartar produces the ſame effect.

It appears that theſe ſalts act only as leavens, to facilitate the decompoſition of the ſaccharine principle.

The juice of grapes is not the only vegetable fluid ſuſceptible of the ſpirituous fermentation.

Apples contain a juice which eaſily ferments, and produces cyder. Wild apples are uſually employed for this purpoſe. Theſe are bruiſed, and the juice preſſed out, which ferments, and exhibits the ſame phenomena as the juice of grapes.

In order to have cyder fine, it is to be decanted off the lees as ſoon as the tumultuous fermentation has ſubſided, and it begins to be clear. Sometimes, in order to render it milder, a certain quantity of the juice of apples recently expreſſed is added, which produces a ſecond fermentation in the cyder leſs ſtrong than the firſt. The cyder which is left to ſtand on the lees acquires ſtrength by that means. Cyder affords the ſame products as wine; but the brandy obtained from it has a diſagreeable flavour, becauſe the mucilage, which is very abundant in the cyder, is altered by the action of the heat of diſtillation. But if it be cautiouſly diſtilled, it affords excellent brandy, according to the experiments of M. Darcet.

The juice of the harſheſt kind of pears affords, by fermentation, a kind of cyder called Perry.

Cherries likewiſe afford a tolerably good wine; and a kind of brandy is obtained from them, which the Germans call Kirchenwaſſer.

In Canada the fermentation of the ſaccharine juice of the maple affords a very good liquor; and the Americans, by fermenting the impure ſyrups of ſugar with two parts of water, form a liquor which affords the ſpirit called Taffia, or Rum, by the Engliſh.

A drink called Beer is likewiſe prepared with certain grain; ſuch as wheat, oats, and barley; but more eſpecially with the latter. 1. The grain is made to ſprout or vegetate, by ſteeping it in water, and placing it in a heap. By this means the glutinous principle is deſtroyed. 2. It is torrefied or ſtoved, to ſtop the progreſs of the fermentation, and fit it for the mill. 3. It is ſifted, to ſeparate the ſprouts or radicles. 4. It is ground into a very coarſe flour, named Malt. 5. The malt is infuſed in hot water, in the maſh-tub. This diſſolves the ſugar and the mucilage, and is called the firſt wort. It is then drawn off, heated, and again poured on the malt, which forms the ſecond wort.* 6. This infuſion, or wort, is boiled with a certain quantity of hops, which communicate an extractive reſinous principle to it. 7. An acid leaven, or ferment, is added, and it is poured into a cooler, where it undergoes the ſpirituous fermentation. When the fermentation has ſubſided, it is ſtirred, and put into caſks, where it continues to ferment, and throws off a frothy ſcum by the bung, which becomes ſour, and ſerves as a ferment for future brewings, under the name of Yeaſt.

The product of all the ſubſtances is a liquor more or leſs coloured, capable of affording ardent ſpirit, by diſtillation, of an aromatic and reſinous ſmell, a penetrating hot taſte, which ſtimulates the action of the fibres.

Wine is an excellent drink, and is alſo uſed as the vehicle of certain medicines. Such are, 1. The emetic wine, which is prepared by digeſting two pounds of good white wine on four ounces of the crocus metallorum: 2. Chalybeated wine, made by digeſting one ounce of ſteel filings in two pounds of white wine: 3. The wines in which plants are infuſed; ſuch as wormwood, ſorrel, and the liquid laudanum of Sydenham, which is made by digeſting for ſeveral days two ounces of ſliced opium, one ounce of ſaffron, one dram of pounded cinnamon and of cloves, in one pound of Spaniſh wine.

---

* In our breweries this practice is uſed only for double ales: and the ſtrengths in other caſes are regulated by the number of times the ſame malt is wetted, and the time of infuſion. The third maſhing affords ſmall beer. T.

We ſhall proceed to examine the conſtituent principles of theſe ſpirituous liquors, by taking that of grapes for an example. The moment the wine is in the caſk, a kind of analyſis takes place, which is announced by the ſeparation of ſome of its conſtituent principles; ſuch as the tartar which is depoſited at the ſides, and the lees which are precipitated to the bottom: ſo that there remain only the ardent ſpirit and the colouring matter diffuſed in a volume of liquid, which is more or leſs conſiderable.

1. The colouring principle is of a reſinous nature, and is contained in the pellicle of the grape; and the fluid is not coloured until the wine is formed; for until then there is nothing which can diſſolve it: and hence it is that white wine may be made of red grapes, when the juice of the grape is expreſſed, and the huſk thrown away.

If wine be evaporated, the colouring principle remains in the reſidue, and may be extracted by ſpirit of wine.

Old wines loſe their colour, a pellicle being precipitated, which is either depoſited on the ſides of the bottles, or falls to the bottom. If wine be expoſed to the heat of the ſun during the ſummer, the colouring matter is detached in a pellicle, which falls to the bottom: when the veſſel is opened, the diſcolouring is more ſpeedy, and it is effected in two or three days during the ſummer. The wine thus deprived of its colour is not perceptibly weakened.

2. Wine is uſually decompoſed by diſtillation: and the firſt product of the operation is known by the name of Brandy.

Brandies have been made ſince the thirteenth century; and it was in Languedoc where this commerce firſt originated. Arnauld de Villeneuve appears to have been the author of this diſcovery. The alembics in which wine was diſtilled conſiſted for a long time of a kind of boiler, ſurmounted with a long cylindric neck, very narrow, and terminating in a hollow hemiſphere, in which the vapours were condenſed. To this ſmall capital was adapted a narrow tube, to convey the fluid into the ſerpentine or worm pipe. This diſtillatory apparatus has been ſucceſſively improved. The column has been conſiderably lowered; and the ſtills generally adopted for the diſtillation of wines in Languedoc are nearly of the following form. The body of the ſtill is flat at bottom, and the ſides riſe perpendicularly to the height of twenty-one inches. At this height the ſides incline inwards, ſo as to diminiſh the opening to twelve inches. This opening ends in a neck of ſeveral inches long, which receives the baſis of a ſmall covering called the head, which approaches to the figure of an inverted cone. From the angle of the upper baſe of the capital, there iſſues a ſmall beak, intended to receive the vapours of brandy, and tranſmit them into the worm-pipe to which it is adapted. This worm-pipe has five or ſix turns, and is placed in a tub, which is kept filled with cold water, to condenſe the vapours.

The body of the ſtill is uſually ſurrounded by the maſonry as high as the neck, and the bottom only is expoſed to the immediate action of the fire. An aſh-hole, which is too ſmall, a fire-place large enough, and a chimney placed oppoſite the door of the fire-place, conſtitute the furnaces in which theſe ſtills are fixed.

The ſtill is charged with between five and ſix quintals of wine; the diſtillation is made in eight or nine hours; and from ſixty to ſeventy-five pounds of pit-coal is conſumed in each diſtillation.

Every judicious perſon muſt be aware of the imperfection of this apparatus. Its principal faults are the following:

1. The form of the body is ſuch as to contain a column of wine of conſiderable height and little breadth, which being acted on by the fire at its baſe, is burned at that part before the upper part is heated.

2. The contraction of the upper part renders the diſtillation more difficult and ſlow. In fact, this inclined part being continually ſtruck by the air, condenſes the vapours, which inceſſantly return into the boiler. It likewiſe oppoſes the free paſſage of the vapours, and forms a kind of eolipile, as Mr. Baumé has obſerved; ſo that the vapours being compreſſed at this narrow neck, react on the wine, and oppoſe its further aſcent.

3. The capital is not conſtructed in a more advantageous manner. The upper part becomes of the ſame temperature as the vapours, which cannot therefore be condenſed, and, by their reaction, either ſuſpend or retard the diſtillation.

4. In addition to this imperfect form of the

apparatus, is joined the moſt diſadvantageous method of adminiſtering the fire. The aſh-hole is every where much contracted; the fire-place is very large, and the door ſhuts badly. In conſequence of this, a current of air paſſes between the combuſtible matter and the bottom of the ſtill, and the flame is driven into the chimney, without being turned to advantage. A violent fire is therefore required to heat the ſtove only to a moderate degree, in this defective conſtruction.

Several other degrees of perfection have been ſucceſſively obtained in the manufactories of Mr. Joubert: but I have judged it poſſible to add ſtill more to what was known; and the following are the principles I ſet out from.

The whole art of diſtillation is reduced to the two following principles:—1. The vapours ought to be diſengaged, and raiſed in the moſt economical manner: 2. And their condenſation ought to be as ſpeedy as poſſible.

To anſwer the firſt of theſe conditions, it is neceſſary that the boiler ſhould preſent the largeſt poſſible ſurface to the fire, and that the heat ſhould be every where equally applied.—2. The ſecond condition requires that the aſcent of the vapours ſhould not be impeded, and that they ſhould ſtrike againſt cold bodies, which ſhall rapidly condenſe them.

The ſtills which I have conſtructed upon theſe principles are more broad than high; the bottom is concave, in order that the fire may be nearly at an equal diſtance from all the points of its ſurface; the ſides are elevated perpendicularly in ſuch a manner that the body exhibits the form of a portion of a cylinder; and this body is covered with a vaſt capital, ſurrounded by its refrigeratory. This capital has a groove or channel, projecting two inches at its lower part within: the ſides have an inclination of ſixty-five degrees; becauſe I have aſcertained that, at this degree, a drop of brandy will run along without falling again into the ſtill. The beak of the capital is as high and as wide as the capital itſelf, and inſenſibly diminiſhes till it comes to the worm-pipe itſelf. The refrigeratory accompanies the beak or neck, and has a cock at its further end, which ſuffers the water to run out, while its place is ſupplied by other cold water, which inceſſantly flows in from above.

When the water of the refrigeratory begins to be warm, a cock is then opened, that it may eſcape in proportion as it is more plentifully ſupplied from above. By this means the water is kept at an equal temperature, and the vapours which ſtrike againſt the ſides of the head are condenſed, at the ſame time that thoſe which riſe ſuffer no obſtacle, as they are ſubjected to no contraction of ſpace. In this conſtruction the worm-pipe may be almoſt diſpenſed with, becauſe the water in the worm-tub does not become perceptibly heated.

Theſe proceedings are very economical and advantageous; for the quality of the brandy is better, and the quantity is larger.

The diſtillation of the wine is kept up until the product is no longer inflammable. This brandy is put into caſks, when it becomes coloured by the extraction of a reſinous principle contained in the wood.

The wine of our climates affords one-fifth or one-fourth of brandy, of the proof ſtrength of commerce.

The diſtillation of brandy by a more moderate heat affords a more volatile fluid, called Spirit of Wine, or Alcohol. To make common ſpirit of wine, brandy is taken and diſtilled on a water bath by diſtillation.* This ſpirit of wine may be purified and rectified by ſubſequent diſtillations, and taking only the firſt portions which come over.

---

* The ardent ſpirit ſold in London by the name of Spirit of Wine, or Lamp Spirit, is made by the rectifiers of malt and melaſſes ſpirit in London, by diſtillation of the reſidues of their compounded ſpirits. It is pretty conſtantly of the ſpecific gravity

Alcohol is a very inflammable and very volatile ſubſtance. It appears to be formed by the intimate union of much hydrogene and carbone, according to the analyſis of Mr. Lavoiſier. This ſame chemiſt obtained eighteen ounces of water by burning one pound of alcohol. If well-dephlegmated alcohol be digeſted upon calcined potaſh, and afterwards diſtilled, a very ſweet alcohol is obtained, and a ſaponaceous extract, which affords alcohol, ammoniac, and an empyreumatic oil. In this experiment, the formation of volatile alkali appears to ariſe from the combination of the hydrogene of the alcohol with the nitrogene of the potaſh.

There are various methods uſed in the arts to judge of the degree of concentration of ſpirit of wine. Gunpowder is put into a ſpoon, and moiſtened with ſpirit of wine, which is ſet on fire: if the powder takes fire, the ſpirit is conſidered

---

gravity of 0,845 at the temperature of 60 Fahrenheit; and may, by very careful rectification, be brought nearly up to 0,820. Dry alkali deprives it of more of its water. On the ſubject of the ſtrength of ſpirits, conſult Blagden in Phil. Tranſ. vol. lxxxi. T.

ſidered to be good; but the contrary, if this effect does not take place. But this method is fallacious, becauſe the effect depends on the proportion in which the ſpirit of wine is uſed: a ſmall quantity always inflames the powder; and a ſtrong doſe never produces this effect, becauſe the water which remains ſoaks into the powder, and defends it from the combuſtion.

The areometer of Mr. Baumé is not to be depended on; becauſe, in the uſe of it, no account is kept of the temperature of the atmoſphere, which, by changing the denſity of the ſpirit of wine, is productive of a change in the reſult as given by this inſtrument. That of Mr. Bories is more accurate, becauſe the thermometer is adapted to it; and it is now uſed in commerce.

Alcohol is the ſolvent of reſins, and of moſt aromatic ſubſtances; and conſequently it forms the baſis of the art of the varniſher and of the perfumer.

Spirit of wine combined with oxigene forms a liquor nearly inſoluble in water, which is called Ether.

Ether has been formed with moſt of the known acids.

The moſt ancient of all is the vitriolic or ſulphuric ether. To make this, a certain quantity of alcohol is put into a retort, and an equal weight of concentrated ſulphuric acid is gradually added. The mixture is ſhaken and agitated, to prevent the retort from breaking by the partial effect of the heat which ariſes. The retort is then placed on a heated ſand bath, a receiver is adapted, and the mixture is heated to ebullition. Alcohol firſt paſſes over; ſoon after which, ſtreams of fluid appear in the neck of the retort, and within the receiver, which denote the riſing of the ether. Its ſmell is agreeable. Vapours of ſulphureous acid ſucceed the ether; and the receiver muſt be taken away the moment they appear. If the diſtillation be continued, ſulphureous ether is obtained, and the oil which is called Etherial Oil, or the ſweet oil of wine; and that which remains in the retort is a mixture of undecompoſed acid, ſulphur and a matter reſembling bitumen.

We ſee that in this operation the ſulphuric acid is decompoſed; and that the oxigene, by combining with the hydrogene and the carbone of the alcohol, has formed three ſtates, which we alſo find in the diſtillation of ſome bitumens—1. A very volatile oil or ether. 2. Etherial oil. 3. Bitumen.

If the ſulphuric acid be digeſted upon ether, it converts the whole gradually into etherial oil.

When the ether is mixed with ſulphureous vapours, it muſt be rectified by a gentle heat; a few drops of alkali being firſt poured in, to combine with the acid.

Sulphuric ether may be made very œconomically, by uſing a leaden ſtill with a head of copper well tinned. In this way I prepare it by the quintal without any difficulty.

Mr. Cadet has propoſed to pour on the reſidue of the retort one third part of good alcohol, and to diſtil it in the uſual way.

Ether is very light, very volatile, and of a pleaſant ſmell. It is ſo eaſily evaporated, that if a fine rag be ſteeped in this liquor, then wrapped round the ball of a thermometer, and the inſtrument be agitated in the air, the thermometer ſinks to the freezing point*.

---

* Mr. Cavallo has deſcribed, in the Philoſophical Tranſ. for 1781, a pleaſing experiment of freezing water by means of ether. The ether is put into a vial ſo as not completely to fill it; and in the neck of this vial is fitted, by grinding, a tube whoſe exterior end is drawn out to a capillary fineneſs. Whenever the bottle thus ſtopped is inverted, the ether is urged out of the tube in a fine ſtream, in conſequence of the preſſure exerted by the elaſtic etherial vapour which occupies the ſuperior ſpace of the bottle. This ſtream is directed on the outſide of a ſmall glaſs tube containing water, which it ſpeedily cools down to the freezing point; at which inſtant the water becomes ſuddenly opake, in conſequence of the

Ether eaſily burns, and exhibits a blue flame. It is very ſparingly ſoluble in water.

Ether is an excellent antiſpaſmodic. It mitigates pains of the colic as if by enchantment, as it does likewiſe external pains. The celebrated Bucquet had accuſtomed himſelf ſo much to this drink, that he took two pints per day: a rare example of the power of habit on the conſtitution.

The mixture of two ounces of ſpirit of wine, two ounces of ether, and twelve drops of etherial oil, forms the anodyne liquor of Hoffman.

Meſſrs. Navier, Woulfe, Laplanche, Bogue, and others, have deſcribed various proceſſes for making nitric ether, which are more or leſs eaſily imitated. For my part, I take equal parts of alcohol, and nitric acid of commerce, of the ſtrength of between thirty and thirty-five degrees. I put the whole into a tubulated retort, which I fit to a furnace, and adapt two receivers one ſucceeding the other. The firſt receiver is immerſed in a veſſel of water. The ſecond is ſurrounded by a wet cloth: and a ſiphon communicates from its tubulure to a veſſel of water in which it is plunged. When the

the icy cryſtallization. If a bended wire be previouſly immerſed in the water, it may afterwards be drawn out, and the ice along with it. T.

heat has penetrated the mixture, much vapours are diſengaged, which are condenſed in ſtriæ, on the internal ſurfaces of the receivers, whoſe external ſurface is kept conſtantly cold. The ether which I obtain is very pure and very abundant*.

When the precaution of diſtilling it properly is attended to, this ether becomes nearly ſimilar to the vitriolic. Meſſrs. de Laſſone and Cornette have obſerved that it was more ſedative.

The diſtillation of the muriatic acid with alcohol produces only a mixture of theſe two liquors, which is called the Dulcified Muriatic Acid.

Before the theory of ethers, and the ſimple proceſs of combining a ſurplus of oxigene with the muriatic acid, were known, methods were invented to procure the muriatic acid; but ſubſtances were always made uſe of in which the muriatic acid was oxigenated. In this manner it was that the baron de Bornes propoſed the concentrated muriate of zinc, mixed and diſtilled with alcohol; and that the marquis de Courtanvaux diſtilled the mixture of a pint of alcohol with two pounds and a half of the fuming muriate of tin.

---

* The ingenious author has forgotten to caution the inexperienced chemiſt againſt the danger of mixing theſe two liquors. The nitrous acid muſt be very gradually added to the ſpirit of wine, by ſmall portions at a time. It is ſaid, and with reaſon, to be of great importance, that the nitrous acid be added to the ſpirit, and not the ſpirit to the acid: for, in this laſt caſe, the mixture will, during the greateſt part of the time of the operation of combining the fluids, conſiſt of a large portion of acid, with a ſmaller portion of ſpirit; whereas, where the contrary method is adopted, the proportion of ſpirit will always be greater than that of the acid, until the laſt quantity of acid is added. T.

The theory of the formation of ether has in our time led to ſimpler proceſſes.

Mr. Pelletier introduces a mixture of eight ounces of manganeſe, and a pound and a half of the muriate of ſoda, in a large tubulated retort; twelve ounces of ſulphuric acid, and eight ounces of alcohol, are afterwards added. Diſtillation is then proceeded on; and ten ounces of a very etherial liquor are obtained, from which four ounces of good ether are afforded by diſtillation and rectification.

The very concentrated muriatic acid, diſtilled from manganeſe in the apparatus of Woulfe, affords more ether. It is even ſufficient, for this purpoſe, to paſs the oxigenated muriatic acid through good alcohol, to convert it into ether.

This muriatic ether has the greateſt analogy with the ſulphuric. It differs from it in two characters only—1. It emits, in burning, a ſmell as penetrating as that of the ſulphuric acid. 2. Its taſte is ſtyptic, reſembling that of alum.

From theſe experiments it is evident that ether is merely a combination of alcohol with the oxigene of the acids made uſe of. I have even obtained an etherial liquor by repeated diſtillations of good alcohol from the red oxide of mercury.

The idea of Macquer, who conſidered ether as ſpirit of wine dephlegmated, or deprived of water, had little foundation: for the diſtillation of the ſpirit of wine from the moſt concentrated or drieſt alkali, never affords any thing but ſpirit of wine more or leſs dephlegmated.

Concerning Tartar.

Tartar is depoſited on the ſides of caſks during fermentation: it forms a lining more or leſs thick, which is ſcraped off. This is called crude tartar, and is ſold in Languedoc from ten to fifteen livres the quintal.

All wines do not afford the ſame quantity of tartar. Neumann remarked that the Hungarian wines left only a thin ſtratum; that the wines of France afforded more; and that the Rheniſh wines afforded the pureſt and the greateſt quantity.

Tartar is diſtinguiſhed, from its colour, into red or white: the firſt is afforded by red wine.

The pureſt tartar exhibits an imperfectly cryſtallized appearance: the form is the ſame as we have aſſigned to the acidulous tartrite of potaſh; and it is this quality which is called grained tartar (tartre grenu) in our refineries at Montpellier.

The taſte of tartar is acid and vinous. One ounce of water, at the temperature of ten degrees above 0 of Reaumur, diſſolves no more than ten grains: boiling water diſſolves more, but it falls down in cryſtals by cooling.

Tartar is purified from an abundant extractive principle by proceſſes which are executed at Montpellier and at Venice.

The following is the proceſs uſed at Montpellier:—The tartar is diſſolved in water, and ſuffered to cryſtallize by cooling. The cryſtals are then boiled in another veſſel, with the addition of five or ſix pounds of the white argillaceous earth of Murviel to each quintal of the ſalt. After this boiling with the earth, a very white ſalt is obtained by evaporation, which is known by the name of Cream of Tartar, or acidulous tartrite of potaſh.

M. Deſmaretz has informed us (Journal de Phyſ. 1771) that the proceſs uſed at Venice conſiſts—1. In drying the tartar in iron boilers. 2. Pounding it, and diſſolving it in hot water, which by cooling affords purer cryſtals. 3. Rediſſolving theſe cryſtals in water, and clarifying the ſolution by whites of eggs and aſhes.

The proceſs of Montpellier is preferable to that of Venice. The addition of the aſhes introduces a foreign ſalt, which alters the purity of the product.

The acidulous tartrite of potaſh cryſtallizes in tetrahedral priſms cut off ſlantwiſe.

This ſalt is uſed by the dyers as a mordant: but its greateſt conſumption is in the north, where it is uſed at table as a ſeaſoner.

Tartar appears to exiſt in the muſt, and conſequently in the grape itſelf. This has been aſcertained by the experiments of De Rouelle and the marquis de Bullion.

This ſalt exiſts in many other vegetables. It is ſufficiently proved that tamariſe and ſumach contain it; and the ſame is true of the barberry, of balm, carduus benedictus, reſtharrow, water-germander, and ſage.

The acidulous tartrite of potaſh may be decompoſed by means of fire, in the way of diſtillation; in which caſe the acid and the alkali are obtained ſeparately. This decompoſition may alſo be effected by the ſulphuric acid.

The celebrated Scheele has deſcribed a proceſs of greater accuracy for obtaining the acid of cream of tartar.

Two pounds of the cryſtals are diſſolved in water, into which chalk is thrown by degrees, till the liquid is ſaturated. A precipitate is formed, which is a true tartrite of lime, is taſteleſs, and cracks between the teeth. This tartrite is put into a cucurbit; and nine ounces of ſulphuric acid, with five ounces of water, are poured on it. After twelve hours digeſtion, with occaſional ſtirring, the tartareous acid is ſet at liberty in the ſolution, and may be cleared of the ſulphate of lime by means of cold water.

This tartareous acid affords cryſtals by evaporation; which, when expoſed to the fire, become black, and leave a ſpongy coal behind.

Treated in a retort, they afford an acid phlegm, and ſome oil.

The taſte of this acid is very ſharp.

It combines with alkalis, with lime, with barytes, alumine, magneſia, &c.

The combination of potaſh with this acid forms cream of tartar, when the acid is in exceſs; which is capable of entering into combinations, and forming triple ſalts. Such is the ſalt of Seignette, or tartrite of ſoda, which cryſtallizes in tetrahedral rhomboidal priſms.

The acidulous tartrite of potaſh is very ſparingly ſoluble in water. Boiling water diſſolves only one twenty-eighth part. The addition of borax has been propoſed to facilitate the ſolution; as likewiſe ſugar, which is leſs efficacious than borax, but makes a very agreeable and purgative lemonade with this ſalt.

ARTICLE II.

Concerning the Acid Fermentation.

The mucilaginous principle is more eſpecially the ſubſtance on which the acid fermentation depends; and when it has been deſtroyed, in old and generous wines, they are no longer capable of alteration, without the addition of a gummy matter, as I find from my own experiments. It is not true, therefore, to ſay that all ſubſtances which have paſſed through the vinous fermentation, are capable of paſſing to the ſtate of vinegar; ſince this change depends on the mucilage, which may not in all caſes be preſent.

There are, therefore, three cauſes neceſſary to produce the acid fermentation in ſpirituous liquors.

1. The exiſtence of mucilaginous matter, or mucilage. 2. A degree of heat between eighteen and twenty-five degrees of Reaumur. 3. The preſence of oxigenous gas.

The proceſs indicated by Boerhaave for making vinegar, is ſtill the moſt frequently uſed. It conſiſts in fixing two caſks in a warm room or place. Two falſe bottoms of baſket-work are fixed at a certain diſtance from the bottom, upon which the refuſe of grapes and vine twigs are placed. One of theſe tuns is filled with wine, and the other only half filled. The fermentation begins in this laſt; and, when it is in full action, it is checked by filling the caſk up with wine out of the other. The fermentation then takes place in the laſt-mentioned caſk, that remained half filled; and this is checked in the ſame manner by pouring back the ſame quantity of liquid out of the other; and in this way the proceſs is continued till the vinegar is made, which is uſually in about fifteen days.

When the fermentation develops itſelf, the liquid becomes heated and turbid; a great number of filaments are ſeen in it; it emits a lively ſmell; and much air is abſorbed, according to the obſervation of the abbé Roſier.

A large quantity of lees is formed, which ſubſides

ſides when the vinegar becomes clear. This lees is very analogous to the fibrous matter.

Vinegar is purified by diſtillation. The firſt portions which paſs over are weak; but ſoon afterwards the acetous acid riſes, and is ſtronger the later it comes over in the diſtillation. This fluid is called Diſtilled Vinegar; and is thus cleared of its colouring principle, and the lees, which is always more or leſs abundant.

Vinegar may likewiſe be concentrated by expoſing it to the froſt. The ſuperabundant water freezes, and leaves the acid more condenſed.

The preſence of ſpirit of wine, mucilage, and air, are neceſſary to form vinegar. Scheele has made it by decompoſing the nitric acid upon ſugar and mucilage. I communicated to the Academy at Paris (vol. 1786) an obſervation of ſome curioſity reſpecting the formation of vinegar. Diſtilled water, impregnated with vinous gas, affords vinegar: at the end of ſome months, a depoſition is made of a ſubſtance in flocks, which is analogous to the fibrous matter of vegetables. When the water contains ſulphate of lime, an execrable hepatic odour is developed, a depoſition of ſulphur is afforded, and all this is owing only to the decompoſition of this ſulphuric acid.

As in the above experiments I had placed the water above the vinous fluid in fermentation, to impregnate it with the carbonic acid, the alcohol which evaporates with the acid carried the mucilage with it; and the effects, I obſerved, are referable to this ſubſtance.

The acetous acid is capable of combining with a ſtronger doſe of oxigene; and then forms radical vinegar, or the acetic acid.

To form the acetic acid, the metallic oxides are diſſolved in the acetous acid; the ſalt which is obtained being then expoſed to diſtillation, affords the oxigenated acid. It has a very lively ſmell, is cauſtic, and its action upon bodies is very different from that of the acetous acid.

This acetic acid has the advantage of forming ether with alcohol. For this purpoſe, equal parts of the acid and alcohol are to be diſtilled together. The product of the diſtillation is to be again added to the reſidue in the retort; and a ſmall quantity of the water of Rabel is likewiſe to be added. The whole becomes converted into ether.

The combination of the acetous acid with potaſh forms the acetite of potaſh.

To make this ſalt, pure potaſh is ſaturated with diſtilled vinegar, the liquor filtered, and evaporated to dryneſs in a glaſs veſſel over a very gentle fire. The acetite of potaſh has a penetrating acid taſte; is decompoſed by diſtillation; and affords an acid phlegm, an empyreumatic oil, ammoniac, and a large quantity of very odorant gas, formed of carbonic acid and hydrogene. The coal contains much fixed alkali in a diſengaged ſtate. This ſalt is very ſoluble in water, and deliqueſces in the air.

The ſulphuric acid poured upon it, decompoſes it; and the products which come over are ſulphuric acid and acetic acid.

The acetous acid likewiſe combines with ſoda; and this combination is improperly called Cryſtallizable Terra Foliata. The acetite of ſoda cryſtallizes in ſtriated priſms, and does not attract the humidity of the air. When theſe ſalts are diſtilled, they leave a reſidue, which forms an excellent and very active pyrophorus.

The acetous acid likewiſe combines with ammoniac. The acetite which is produced is called the Spirit of Mindererus. This ſalt cannot be evaporated without the loſs of a conſiderable part, on account of its volatility: but, by a long evaporation, it affords needle-formed cryſtals, of a hot and penetrating taſte, and attracting moiſture from the air. Lime, fixed alkalis, mere heat or fire, and the acids, decompoſe this ſalt.

The ſulphate of potaſh, ſprinkled with the acetic acid, forms the ſalt of vinegar.

ARTICLE III.

Concerning the Putrid Fermentation.

In order that vegetables may undergo the two fermentations we have treated of, it is neceſſary that the juices ſhould be extracted, and preſented in a conſiderable volume. A due degree of heat, together with other circumſtances artificially brought together, are likewiſe neceſſary; for a grape, left on the ſtalk, produces neither ardent ſpirit nor vinegar, but rots. It is this new kind of alteration we ſhall at preſent proceed to treat of.

This fermentation is the moſt natural termination of the vegetable. It is indeed the only end to which the natural courſe of things is directed; ſince it is by this means that the exhauſted ſurface of the globe is repaired. The two other fermentations are the mere effects of art, and form no part of the great plan of nature.

The life of the greateſt part of vegetables laſts but a few months; but the ſeeds they depoſit aſſure their re-production. There are other more robuſt vegetables which ſupport the cold of winter, and only caſt their leaves at that period. The annual vegetables, and vivacious plants, are altered by the combined action of the cauſes we have mentioned; and the reſult, according to the degree of decompoſition, is either manure, vegetable earth, or ochre.

The conditions of the vegetable fermentation are the following:

1. It is neceſſary that the organization be impregnated with water. Dried vegetables are preſerved without putrefying; and, if they be moiſtened, their ſubſequent alteration is prodigiouſly accelerated. In this manner it is that plants heaped together become heated, blacken, and take fire, if not ſufficiently dried. Fires of this kind are not rare, and the theory is not difficult to be explained. Wetted ropes, moiſt hay heaped together, and in a word every vegetable ſubſtance, putrefies or rots with greater facility, the more perfectly its texture is impregnated with water.

2. The contact of air is the ſecond neceſſary cauſe in the putrefaction of vegetables. It is reported, in the Ephemerides of the Curious in Natural Phenomena, for 1787, that ripe cherries were preſerved for forty years, by incloſing

them in a veſſel well luted, and placed at the bottom of a well.

3. A certain degree of heat is likewiſe neceſſary. The heat between five and ten degrees is ſufficient to cauſe decompoſition. A greater heat diſſipates the humidity, dries the vegetable, and preſerves it from putrefaction. Too little heat retards or ſuſpends it.

4. It is likewiſe neceſſary, for the due effect of this decompoſition, that the vegetables ſhould be heaped together, and their juices abundant. A greater quantity of air is then combined with the vegetable: becauſe the juices and the ſurfaces are then more conſiderable; and conſequently a greater degree of heat is produced, which accelerates the decompoſition.

When vegetables are heaped together, and their texture is ſoftened by the humidity with which they are impregnated, together with their own juices, the phenomena of decompoſition are the following:—The colour of the vegetable is changed; the green leaves become yellow, the texture becomes lax, and the parts leſs coherent; the colour of the vegetable itſelf changes to black or brown; the maſs riſes, and perceptibly ſwells up; the heat becomes more intenſe, and is perceived on approaching the heap; and the fumes which ariſe have already a ſmell, which ſometimes is not diſagreeable; at the ſame time bubbles ariſe, and break at the ſurface of the liquid, when the vegetables are reduced to a magma. This gas is a mixture of nitrogene, hydrogene, and carbonic acid. At this epocha, likewiſe, an ammoniacal gas is emitted, which is formed in theſe circumſtances: and, in proportion as theſe appearances diminiſh, the ſtrong and offenſive odour is ſucceeded by another which is fainter and milder, and the maſs becomes dry. The internal part ſtill exhibits the vegetable ſtructure, when the ſtem is ſolid, and the fibrous matter has been the predominating principle; and it then conſtitutes manure or ſoil. Hence it ariſes that the herbaceous plants of a looſe texture, and abounding in juices, are not capable of forming manure by their decompoſition, but are reduced into a brown maſs of little conſiſtence, in which neither fibre nor texture are obſerved; and this is what, for the moſt part, forms vegetable mould.

Vegetable mould uſually conſtitutes the firſt covering or ſtratum of our globe; and in ſuch caſes wherein it is diſcovered at a depth in the earth, there is no doubt but it has been buried by ſome revolution.

When a vegetable is converted into earth by this tumultuous fermentation, it ſtill retains the remains of the vegetable, mixed and confounded with the other ſolid earths and metallic products; and by diſtillation it affords oil, nitrogene gas, and often hydrogene. It may therefore be conſidered as an intermediate ſubſtance, between crude and organic bodies, which participates of the inertia of the one, and the activity of the other; and which in this ſtate is ſtill ſubject to an inſenſible fermentation, that changes its nature ſtill more, and deprives it of all its organic contents. Theſe remains of vegetables ſtill contained in vegetable earth, ſerve as food for other plants that may grow in it. The inſenſible progreſs of fermentation, and the ſuction of vegetables, impoveriſh the vegetable earth, deprive it of all its organic matter, and there remain only the earths and metallic reſidue which form the ſtiff poor ſoils, and ochres when the ferruginous principle is very abundant.

As this muddy earth is a mixture of all the primitive earths, and ſome of the metals which are the product of vegetation, as well as the oils, the ſalts, and other products we meet with in it; we may conſider it as the reſidue of vegetable decompoſition, as the great agent and means by which nature repairs the continual loſſes the mineral kingdom undergoes. In this mixture of all the principles the materials of all compounds exiſt; and theſe materials are ſo much the more diſpoſed to enter into combinations, as they are in a more divided and diſengaged ſtate. It is in theſe earths that we find diamonds, quartz-cryſtals, ſpars, gypſum, &c. It is in this matrix that the bog ores, or ochreous ores of iron, are formed; and it appears that nature has reſerved the impoveriſhed reſidue of vegetables for the reproduction or reparation of the earthy and metallic ſubſtances of the globe, while the organic remains are made to ſerve as nouriſhment for the growth of other ſucceeding vegetables.

PART VI.

CONCERNING ANIMAL SUBSTANCES.

INTRODUCTION.

THE abuſe which, at the commencement of this century, was made of the application of chemiſtry to medicine, occaſioned, a ſhort time afterwards, that all the relations between this ſcience and the art of healing were miſtaken and rejected. It would no doubt have been more prudent, as well as more uſeful, to have connected theſe miſtaken applications: but chemiſtry was not perhaps at that time in a ſufficiently advanced ſtate, to be advantageouſly applied to the phenomena of living bodies; and, even at this day, we ſee that, though the phyſiology of the human body is enriched with various intereſting facts, there is ſtill much to be done before they will be ſufficiently numerous to exhibit a ſatisfactory maſs of doctrine.

The imperfect ſucceſs of chemiſtry in that branch of the Science which has the ſtudy of man for its object, ariſes from the very nature of the ſubject itſelf. Some chemiſts, by conſidering the human body as a lifeleſs and paſſive ſubſtance, have ſuppoſed the humours to undergo the ſame changes as they would have been ſubject to out of the body; others, from a very ſuperficial knowledge of the conſtitution of theſe humours, have pretended to explain all the phenomena of the animal œconomy. All have miſtaken or overlooked that principle of life which inceſſantly acts upon the ſolids and fluids; modifies, without ceaſing, the impreſſion of external objects; impedes the degenerations which depend on the conſtitution itſelf; and preſents to us phenomena which chemiſtry never could have known or predicted by attending to the invariable laws obſerved in inanimate bodies.

None of the bodies of the mineral kingdom are governed by an internal force. They are all ſubjected to the direct action of foreign ſubſtances, without any modification from any vital principle; and the air, water, and fire, produce in them effects which are neceſſary, conſtant, and ſubject to calculation: whence it happens that we are able to determine, modify, and vary the action of theſe various agents at pleaſure. It is not the ſame with living bodies: they are all indeed ſubject to the influence of external bodies; but the effect of theſe is modified by the reaction of the vital principle, and is varied according to the diſpoſition of that principle. The chemiſt cannot therefore determine theſe effects *à priori*, and in a general way. He muſt ſearch for his reſults rather in the living body itſelf than in the operations of his laboratory; and can have no aſſiſtance from his analyſis but in aſcertaining the nature of their component parts. But their action, effects, or tranſpoſitions, can only be known by a ſerious ſtudy of the functions of the living body. Chemiſtry can perform every thing in the mineral kingdom, becauſe every thing depends on the laws of the affinities. But, in the kingdoms of organized beings, this ſcience is ſubordinate to the laws of the œconomy of living bodies; and its reſults can only be affirmed to be true, when they are confirmed by obſervation.

The more the functions of the individual are independent of organization, the leſs is the empire of chemiſtry over them, becauſe the effects are modified in a thouſand ways; and it is this which renders the application of chemical principles to the phenomena of the human body ſo very difficult: for the organization is not only very complicated, but the effects are continually varied by the powerful influence of the mind.

There is not however any function in the animal œconomy, upon which the ſcience of chemiſtry cannot throw ſome light. If we conſider them in the healthy ſtate, we ſhall perceive that every organ produces ſome change in the humours it receives; and, though the chemiſt may indeed be ignorant of the manner in which ſuch changes are produced, it is by his art alone that the difference between the original fluid, and that which has been elaborated, can be aſcertained. Beſides which, the functions of the various organs are exerciſed upon external objects, and theſe objects come under the conſideration of chemiſtry. We are at preſent, for example, acquainted with the nature of the air which ſerves for reſpiration, its effects on the lungs, and its influence on the animal œconomy. We are even now able to determine whether any air be good or bad, and know how to correct that which is vitiated, &c. We likewiſe poſſeſs ſome accurate ideas of the nutritive principle of certain ſubſtances; and chemiſtry teaches us how to diſpoſe of the reſpective aliments, and adapt them to the various circumſtances. The analyſis of waters is ſufficiently perfect to admit of our diſtinguiſhing the properties of that fluid relative to health, and to ſelect the beſt for our own uſe: ſo that, while the principle of life preſides over and governs all the internal operations of the human body by a mechaniſm which is very imperfectly known to us, we ſee nevertheleſs that all the functions receive an impreſſion more or leſs direct from external objects; that all the materials uſed for the ſupport of the machine are ſupplied from without; that the principle of life which collects and diſpoſes of theſe materials, after laws unknown to us, is capable neither of chooſing nor rejecting them; and that the functions would be very ſpeedily altered, if chemiſtry, founded on obſervation, were not careful to remove the noxious, and ſelect ſuch bodies as are of advantage to the ſyſtem. Chemiſtry therefore can do nothing in the arrangement of the materials, but poſſeſſes unlimited power in their ſelection and preparation.

When the organization is deranged, this defect of order can ariſe only from external or internal cauſes. In the firſt caſe, the analyſis of the air, the water, and the foods, will afford accurate notions ſufficient to re-eſtabliſh the functions. In the ſecond, the chemical examination of the humours may afford information ſufficient to direct the phyſician in pointing out the moſt ſuitable remedy. Sometimes the humours are decompoſed in the body, as *in vitro.* We obſerve all the phenomena of a degeneration and complete diſunion of the principles which compoſe the blood, in the ſcurvy, cachexy, malignant fevers, &c. It ſeems as if, in ſuch caſes, the vital principle abandoned the government, and left the ſolids and fluids to the deſtructive action of external agents; in conſequence of which they become decompoſed in the ſame manner as they uſually do when ſeparated from the body.

When the principle of animality is once extinguiſhed, the ſame cauſes which maintained the functions, and whoſe effects were modified by that principle of life, now act with their whole energy on the body, and decompoſe it. Chemiſtry has diſcovered methods of extracting from theſe dead bodies a variety of ſubſtances of uſe in the arts and in pharmacy.

Chemiſtry is therefore applicable to the animal œconomy in the ſtate of health and in the ſtate of ſickneſs.

The chemical art has marked the limits between vegetable and animal ſubſtances. Theſe laſt afford ammoniac by putrefaction, while the fermentation of the former develops ardent ſpirit. The latter leave a coal which burns eaſily; while the former become converted into a coal almoſt incombuſtible. Animal matters contain much nitrogene, which may be diſengaged by means of nitric acid. The intereſting Memoirs of Meſſ. Berthollet and De Fourcroy on animal ſubſtances, may be conſulted to great advantage.

CHAP. I.

Concerning Digeſtion.

THAT humour which is known by the name of the Gaſtric Juice, is ſeparated by glands placed between the membranes which line the ſtomach; and from theſe it is emitted into the ſtomach itſelf.

In order to obtain the gaſtric juice in a ſtate of purity, the animals intended to furniſh it are kept faſting for two days, after which the ſtomach is extracted. In this manner Spallanzani obtained thirty-ſeven ounces of this juice out of the two firſt ſtomachs of a ſheep. The ſame naturaliſt cauſed animals to ſwallow thin tubes of metal, pierced with ſeveral holes, into which he had put ſmall ſponges, very clean and dry. He cauſed crows to ſwallow eight at a time, which were vomited up at the end of three hours and a half. The juice which he obtained was yellow, tranſparent, ſalt, bitter, and leaving very little ſediment, when the bird was faſting. The gaſtric juice may likewiſe be procured by the vomiting which is excited by irritation during faſting. M. Scopoli has obſerved that the moſt fluid part only is thrown up by irritation; and that the thicker part does not quit the ſtomach but by the aſſiſtance of an emetic. M. Goſſe, who had long accuſtomed himſelf to ſwallow the air, which anſwered the purpoſe of an emetic with him, has availed himſelf of this habit to make ſome experiments with the gaſtric juice. He ſuſpends his reſpiration, receives air into his mouth, and puſhes it towards the pharinx with his tongue. This air, rarefied in his ſtomach, produces a convulſive motion, which clears it of its contents. Spallanzani has obſerved that eagles ſpontaneouſly emit a conſiderable quantity of gaſtric juice, when faſting in the morning.

We are indebted to Reaumur and the abbé Spallanzani for very intereſting experiments reſpecting the virtue and effects of the gaſtric juice in digeſtion. They cauſed animals to ſwallow tubes of metal, perforated in various places, and filled with aliments, to examine their effects. The philoſopher of Pavia uſed purſes of thread, and bags of linen and of woollen. He himſelf ſwallowed ſmall purſes filled with fleſh boiled or raw, with bread maſticated, and alſo in its original ſtate, &c: and likewiſe ſmall cylinders of wood, five lines in length and three in diameter, pierced with holes, and covered with cloth.

M. Goſſe, availing himſelf of the facility with which he was able to vomit by means of the air, has taken all kinds of food, and examined the changes they had undergone, by returning them after intervals more or leſs remote from the time of deglutition.

From theſe various experiments it follows—1. That the gaſtric juice reduces the aliments into an uniform magma, even out of the body, and *in vitro*; and that it acts in the ſame manner on the ſtomach after death: which proves that its effect is chemical, and almoſt independent of vitality. 2. That the gaſtric juice effects the ſolution of the aliments included in tubes of metal, and conſequently defended from any trituration. 3. That though there is no trituration in membranous ſtomachs, this action powerfully aſſiſts the effect of the digeſtive juices in animals whoſe ſtomach is muſcular, ſuch as ducks, geeſe, pigeons, &c. Some of theſe animals bred up with ſufficient care that they might not ſwallow ſtones, have nevertheleſs broken ſpheres and tubes of metal, blunted lancets, and rounded pieces of glaſs, which were introduced into their ſtomachs. M. Spallanzani has aſcertained that fleſh included in ſpheres ſufficiently ſtrong to reſiſt the muſcular action, was completely digeſted. 4. That the gaſtric juice acts by its ſolvent power, and not as a ferment: becauſe the ordinary and natural digeſtion is attended with no diſengagement of air, nor inflation, nor heat, nor in a word with any of the phenomena of fermentation.

M. Scopoli obſerves very well that nothing poſitive or certain can be aſſerted reſpecting the nature of the gaſtric juice. It is ſometimes acid and ſometimes inſipid. M. Brugnatelli has found in the gaſtric juice of carnivorous birds, and ſome others, a diſengaged acid, a reſin, and an animal ſubſtance, united with a ſmall quantity of common ſalt. The gaſtric juice of ruminating animals contains ammoniac, an extractive animal ſubſtance, and common ſalt. In our time the phoſphoric ſalts have been found diſengaged in the gaſtric juice.

It appears, from the obſervations of Meſſrs. Spallanzani and Goſſe, that the nature of the gaſtric juice varies according to that of the aliments. This juice is conſtantly acid when the diet is vegetable. The abbé Spallanzani affirms, contrary to Meſſrs. Brugnatelli and Carminati, that birds of prey have never afforded him an acid juice; and he affirms the ſame of ſerpents, frogs, fiſhes, *&c*.

In order to ſhew clearly that there is a great difference between the gaſtric juices of various animals, it is ſufficient to obſerve that the gaſtric juice of the kite, the falcon, &c. does not diſſolve bread, though it digeſts fleſh meat; and that the gaſtric juice of the turkey, the duck, &c. has no action upon fleſh, but converts the hardeſt grain into a pulp.

Meſſrs. Jurine, Toggia, and Carminati have made the moſt ſucceſsful applications of the gaſtric juice in the treatment of wounds.

CHAP. II.

Concerning Milk.

OF all the animal humours, milk is beyond contradiction the leaſt animalized. It appears to partake of the nature of chyle; it preſerves the qualities and character of the aliments; and for this reaſon we are induced to place it at the head of the humours of animal bodies.

Milk is ſeparated in organs called breaſts or udders; and though the claſs of animals with breaſts exhibits the greateſt analogy in the internal conſtruction of theſe organs, yet the milk varies in the ſeveral ſpecies. In the human ſpecies it is more ſaccharine; in the cow, milder or ſofter: the milk of the goat, and of the aſs, are ſlightly aſtringent: and it is for this reaſon that they are ordered to be taken in diſorders which have weakened and exhauſted the human frame*.

Milk is the firſt food of young animals. Their weak and feeble ſtomachs are incapable of digeſting and aſſimilating aliments afforded by the earth ; and nature has accordingly provided them a food more animalized, and conſequently more analogous to their ſtructure, until their increaſed ſtrength permits them to uſe a coarſer food.

---

* It ſeems moſt probable that the pre-eminence ſtill given to the milk of the aſs, ariſes from no better reaſon than the loud and ſonorous voice of the animal, which, by a kind of reaſoning very common among the ancient phyſicians, has led to a concluſion that the milk of ſuch a creature muſt be good for the lungs. The root ſatyrion, the milk of the goat, and many other ſubſtances, formerly ſtood high in medical eſtimation, for reaſons equally obvious and equally ſuperficial. It muſt not however be denied but that, when the poſſeſſor of an exhauſted conſtitution becomes ſo far obedient to advice as regularly to take aſſes milk, and attend to other circumſtances of regimen, he may find himſelf benefited; and the aſſes milk, merely as milk, ſubſtituted inſtead of ſome leſs friendly beverage or food, may be entitled to a ſhare in the general effect. T.

Hunter has obſerved that all the animals which diſgorge to feed their young, have glands in the ſtomach, which are formed during the incubation, and afterwards gradually obliterated.

Milk is in general of an opake white colour, and ſaccharine taſte.

By attending to the various alterations it undergoes when left to itſelf, or when decompoſed by chemical agents, we may arrive at a perfect knowledge of its nature.

Milk expoſed to the air is decompoſed in a longer or ſhorter time, according to the degree of heat of the atmoſphere. But if the temperature of the atmoſphere be hot, and the milk in large quantity, it may paſs to the ſpirituous fermentation. Marco Polo, the Venetian, who wrote in the thirteenth century, affirms that the Tartars drink mares milk, ſo well prepared that it might be taken for white wine. Claude Strahelenberg reports that the Tartars extract a vinous ſpirit from milk, which they call Arki (Deſcription de l'Empire de Ruſſie). John George Gmelin, in his Voyage to Siberia, affirms that the milk is ſuffered to become ſour, and is afterwards diſtilled.

M. Nicolas Oſeretſkowſky, of St. Peterſburg, has proved—1. That milk deprived of its cream cannot produce ardent ſpirit, either with a ferment or without. 2. That milk agitated in a cloſe veſſel affords ardent ſpirit. 3. That fermented milk loſes its ſpirituous principle by heat, and paſſes to the ſtate of vinegar.—Journal de Phyſ. 1779.

Milk becomes ſour in the ſummer, and in three or four days the acid has acquired all its ſtrength. If the whey be then filtered, and evaporated to half, cheeſe is depoſited. If it be again filtered, and a ſmall quantity of the tartareous acid be added, a quantity of ſmall cryſtals of tartar are ſeen to be formed in the courſe of an hour afterwards, which according to Scheele can (not) ariſe only from the ſmall quantity of muriate potaſh (in milk, but from an eſſential ſalt*) which milk always contains.

To ſeparate the various principles contained in ſour whey, the following proceſs may be uſed, which was pointed out by the celebrated Scheele.

---

* The words in the parentheſes are added, to render the text conformable to Scheele's Eſſay. T.

Evaporate the ſour milk to one eighth. All the acid ſeparates, and remains on the filtre. Pour lime water on the reſidue ; an earth is precipitated, and the lime combines with the acid. The lime may be diſplaced by the oxalic acid, which forms with it an inſoluble oxalite, which falls down, and the acid of milk remains diſengaged. The fluid is then to be evaporated to the conſiſtence of honey, and upon this very pure alcohol is to be poured. The ſugar of milk, and all the other principles, are inſoluble, except the acid. The maſs being then filtered, the acid of milk may be ſeparated from its ſolvent by diſtillation. This is the acid known by the name of Lactic Acid. It poſſeſſes the following characters.

1. When ſaturated with pot-aſh, it affords a deliqueſcent ſalt, ſoluble in alcohol.

2. With ſoda, a ſalt not cryſtallizable, and ſoluble in alcohol.

3. With ammoniac, a deliqueſcent ſalt, which ſuffers moſt of its alkali to eſcape before the heat has deſtroyed the acid.

4. Barytes, lime, and alumine, form with it ſalts which are deliqueſcent.

5. Magneſia affords ſmall cryſtals, which are reſolved into a liquor.

6. Biſmuth, cobalt, antimony, tin, mercury, ſilver, and gold, are not attacked by it either hot or cold.

7. It diſſolves iron and zinc, and produces hydrogenous gas. The ſolution of iron is brown, and does not afford cryſtals: that of zinc cryſtallizes.

8. With copper it aſſumes a blue colour, which changes to green, and afterwards to an obſcure brown, without cryſtallizing.

9. When kept in digeſtion upon lead for ſeveral days, it diſſolves it. The ſolution does not afford cryſtals. A light ſediment of a white colour is formed, which Scheele conſiders as a ſulphate of lead.

Whey not ſour contains a ſaline ſubſtance, known by the name of Sugar of Milk. Meſſrs. Valgamoz and Lichtenſtein have deſcribed the proceſs uſed to obtain this ſaline ſubſtance. The milk is deprived of its cream in the uſual manner, and of its curd by rennet. It is then concentrated by evaporation till it has acquired the conſiſtence of honey, after which it is put into moulds, and dried in the ſun. This is called Sugar of Milk in Cakes (ſucre de lait en tablettes). Theſe cakes are diſſolved in water, clarified with white of egg, evaporated to the conſiſtence of ſyrup, and ſet to cryſtallize in a cool place. It affords white cryſtals in rhomboidal parallelopipedons.

Sugar of milk has a ſlightly ſaccharine taſte, inſipid, and as it were earthy. It is ſoluble in three or four pints[*] of hot water. M. Rouelle obtained from twenty-four to thirty grains of aſhes from one pound of this ſalt burned. Three-fourths conſiſted of muriate of potaſh, and the reſt was corbonate of potaſh.

Sugar of milk exhibits the ſame appearances as ſugar, either by diſtillation, or on the fire. This ſalt[†], treated with the nitric acid, afforded me three gros of oxalic acid in the month of July 1787 (*Mémoire préſenté à la Société Royale des Sciences de Montpellier*). Scheele obſerved the ſame fact nearly at the ſame time. I obtained it in beautiful cryſtals; Scheele, in the form of a white powder[‡].

---

[*] By an overſight for *parts*. T.

[†] The quantity of ſalt uſed is not put down. Scheele obtained five drachms of acid of ſugar in long cryſtals, by diſtilling nitrous acid from twelve ounces of ſugar of milk, and ſeven drachms and a half of the peculiar *acid of ſugar of milk* in a white powder. The memoir of Scheele is dated 1780. T.

[‡] I do not ſee by what overſight it is that our ingenious author

If ſix ſpoonfuls of good alcohol be mixed with three pints of milk, and the mixture be expoſed to heat in cloſe veſſels, with the attention to give, from time to time, a ſlight vent to the gas of the fermention; the milk

---

author ſeems to confuſe the two ſalts together, which are afforded by treating the ſugar of milk with nitrous acid. One, as obſerved in the preceding note, is the oxalic or ſaccharine acid, and the other the acid of ſugar of milk. The properties of this laſt (Scheele's Eſſays, London, 1786) are the following:

1. It is combuſtible like oil in a red-hot crucible, without leaving any mark of aſhes behind. 2. Sixty parts of boiling water, or eighty of cold water, are required to diſſolve it. 3. Its taſte is ſouriſh, it reddens tincture of litmus, and efferveſces with chalk. 4. By deſtructive diſtillation it melts, grows black, froths very much; a brown ſalt, ſmelling like a mixture of flowers of benzoin and acid of amber, ſublimes; a brown liquid, without any appearance of oil, comes over into the receiver, and is found to contain ſome of the ſame kind of ſalt as was ſublimed. The ſublimed ſalt is acid, eaſily ſoluble in ardent ſpirit, but more difficultly in water, and burns in the fire with a flame. 5. With all the ſoluble earths it forms ſalts inſoluble in water. 6. With vegetable alkali it forms a perfectly neutral cryſtallizable ſalt, ſoluble in eight times its weight of boiling water, and ſeparable for the moſt part by cooling. 7. With mineral alkali it forms a ſalt which requires only five parts of boiling water for its ſolution. 8. With volatile alkali it forms a ſalt which, after being gently dried, has a ſouriſh taſte. 9. It does not perceptibly act on the metals; but forms, with their calces, ſalts of very difficult ſolubility, which therefore fall down. T.

is found, in the courſe of a month, to be changed into good acetous acid, according to Scheele.

If a bottle be filled with freſh milk, and inverted beneath the ſurface of milk in an open veſſel, and this be ſubjected to a degree of heat a little exceeding that of ſummer, at the end of twenty-four hours the milk is found to be coagulated; the gas which is developed diſplaces the milk: a proof, according to Scheele, that the vinous fermentation has taken place.

To decompoſe milk, and ſeparate its various conſtituent parts, rennet, or the milk turned ſour in the ſtomach of calves, is commonly made uſe of. For this purpoſe the milk is warmed, and twelve or fifteen grains of rennet is added to each pint. Gallium, the flowers of thiſtle or artichokes, and the internal membrane of the ſtomach of birds dried, and reduced to powder, &c. are among the ſubſtances which may be uſed to turn milk. The whey obtained in this manner is turbid; but may be clarified by boiling it with white of egg, and ſubſequent filtration.

On the mountain of Larzac I have ſeen the dairy woman plunge her arms up to the elbows in the milk, and change their place from time to time. This was done with a view to haſten the ſeparation of the principles; and it is probable that the heat, and perhaps certain emanations from the arm itſelf, might favour that effect.

The ſolid maſs which ſeparates from whey, contains two other ſubſtances very intereſting to be known; namely, cheeſe and butter.

If any vegetable or mineral acid be put into milk, a coagulation follows, as is well known. The only difference is, that the mineral acid affords leſs cheeſe or curd than the vegetable; and the various ſubſtances uſed to coagulate milk, may perhaps act merely by virtue of the acid they contain. Olaus Borrichius obtained an acid from curdled milk at a degree of heat incapable of decompoſing it. The coagulum which is afforded in all theſe caſes, contains a ſubſtance of the nature of gluten, which forms the cheeſe; and another ſubſtance of the nature of oils, which forms the butter. When cheeſe is prepared for the table, the butter is not ſeparated, becauſe it renders it milder and more agreeable.

The cauſtic alkalis diſſolve cheeſe by the aſſiſtance of heat. But it is not held in ſolution by an alkali in milk.

If one part of cheeſe newly ſeparated, and not dried, be mixed with eight parts of water ſlightly acidulated by a mineral acid, and the mixture be boiled, the cheeſe will be diſſolved, though it would not have been ſenſibly acted on by a vegetable acid. This is the cauſe why the vegetable acids ſeparate a much greater quantity of curd from the ſame quantity of milk than the mineral acids do.

The cauſe why ſalts, gums, ſugar, &c. coagulate milk, may be deduced from the greater affinity of the water with theſe bodies than with the cheeſe.

The earth of cheeſe is a phoſphate of lime, according to Scheele.

No ſubſtance has a ſtronger reſemblance to cheeſe than the white of egg boiled. White of egg is diſſolved in diluted acid, and alſo in cauſtic alkali, and in lime-water, and is precipitated from them by acids.

Scheele thinks that the coagulation of white of egg, lymph, and cheeſe, is owing to the combination of caloric; and he proves his opinion as follows:—Mix one part of white of egg with four parts of water; pour in a ſmall quantity of pure alkali; add as much muriatic acid as is neceſſary to ſaturate it, and the white of egg will coagulate. In this experiment there is a change of principles. The heat of the alkali combines with the white of egg, and the alkali with the muriatic acid*.

Ammoniac diſſolves cheeſe more effectually than fixed alkalis. If a few drops be poured into coagulated milk, it quickly cauſes the coagulum to diſappear.

Concentrated acids likewiſe diſſolve it. Nitric acid diſengages nitrogene.

The curd dried, and placed in a proper ſituation to undergo a commencement of the putrid fermentation, acquires conſiſtence, taſte, and colour. In this ſtate it is uſed at table by the name of Cheeſe.

At Roquefort, where I have attended the manipulations of the excellent cheeſe which is made there, care is taken to preſs the curd well, in order to expel the whey, and to dry it as accurately as poſſible. After this it is taken into caves, where the temperature is two or three degrees above o. The fermentation is developed by a ſmall quantity of ſalt. The putrefaction is ſuſpended by ſcraping the ſurface from time to time; and the fermentation thus governed by art, and kept under by the coolneſs of the caves, produces a ſlow effect upon all the cheeſe, and ſucceſſively develops the red and blue colours, of which I have given the etiology in a Memoir on the Fabrication of Cheeſe at Roquefort, preſented to the Royal Society of Agriculture, and printed in the fourth volume of *Annales Chimiques*.*.

---

* The reaſoning of Scheele is more fully this:—Heat coagulates white of egg, without diminiſhing its weight: whence he concludes coagulated white of egg to be a combination of heat with white of egg. Acids expel heat from cauſtic alkalis when they combine with them, but not from mild alkalis. A very dilute alkali is uſed in this experiment, that the temperature may not be raiſed, and nevertheleſs the effect takes place; but it does not when a mild alkali is uſed. Whence he concludes that the heat of the cauſtic alkali, inſtead of being employed to raiſe the temperature, has entered into combination with the white of egg, and coagulated it. T.

Butter is the third principle contained in milk. It is ſeparated from the ſcum and the caſeous matter by rapid agitation. The ſubſtance called cream is a mixture of cheeſe and butter which floats on the top of the milk. Violent agitation converts this into froth; in which ſtate it is called *whipped cream*.

Butter has a ſoft conſiſtence, is of a yellow golden colour, more or leſs deep, of a mild agreeable flavour, melts eaſily, and becomes ſolid again by mere cooling.

Butter is eaſily changed, and becomes rancid like oils. The acid which is developed may be carried off by water, or by ſpirit of wine, which diſſolve it. Fixed alkali diſſolves butter, and forms a ſoap little known.

---

* It is in the fourth volume of the *Annales de Chimie* that the author has inſerted an extract from his excellent Memoir on this ſubject. T.

Diſtillation affords a coloured concrete oil from butter, and a ſtrong pungent acid. This oil, by repeated diſtillation, becomes altered, and reſembles volatile oils.

Milk is therefore a mixture of oil, lymph, ſerum, and ſalt. This mixture is weakly united, and the union between the principles is eaſily deſtroyed. Milk is ſaid to be *turned* when the diſunion of its principles is effected by mere repoſe: but when this ſeparation is made by reagents, it is ſaid to be *curdled** or coagulated.

CHAP. III.

Concerning the Blood.

BLOOD is that red humour which circulates in the human body by means of the arteries and veins, and ſupports life by ſupply-ing all the organs with the peculiar juices they demand. It is this humour which receives the product of digeſtion from the ſtomach, which it elaborates and animalizes. This humour is with reaſon conſidered as the focus of life. The difference of temperaments with regard to the paſſions, has been attributed to it by all the philoſophers who have treated this ſubject. It is in vain that phyſicians have changed their ſyſtem; for the opinions of the people have been leſs verſatile, and they have continued to attribute all the ſhades of temperament to the modifications of the blood. It is likewiſe to the alterations of this humour that phyſicians have for a long time aſcribed the cauſe of almoſt every malady. It is more eſpecially entitled to the attention of the chemiſt.

---

* *Lait tourné* and *lait caillé.* This diſtinction ſcarcely obtains in the Engliſh language. T.

The blood varies in the ſame individual, not only with regard to the ſtate of health, but likewiſe at the ſame inſtant. The blood which circulates through the veins has not the ſame intenſity of colour, nor the ſame conſiſtence, as that of the arteries; that which flows through the organs of the breaſt differs from that which paſſes languidly through the viſcera of the lower belly.

The blood differs alſo—1. According to the age. In infancy it is paler and leſs conſiſtent.

2. According to the temperament. Sanguine perſons have the blood of a vermillion red; in the phlegmatic it is paler; and in the choleric it is more yellow.

The temperature of the blood is not the ſame in the ſeveral ſpecies of animals. Some have the blood hotter, and ſome colder, than the medium in which they live. Animals with lungs have the blood redder and hotter than thoſe which are without that organ; and the colour and heat are in proportion to the extent and perfection of the lungs, as M. Buffon and Brouſſonet have obſerved.

The blood putrefies by a gentle heat. If it be diſtilled on the water bath, it affords phlegm of a faint ſmell, which eaſily putrefies. Blood dried by a proper heat effervеſces with acids; if expoſed to the air, it attracts humidity; and at the end of ſeveral months a ſaline effloreſcence is formed, which Rouelle has aſcertained to be ſoda. If the diſtillation of blood be carried farther, the product is acid, oil, carbonate of ammoniac, &c. A ſpongy coal remains in the retort, of very difficult incineration, in which are found ſea ſalt, carbonate of ſoda, iron, and phoſphate of lime.

Alcohol and the acids coagulate the blood: alkalis render it more fluid.

But if the blood received in a ſhallow baſon be obſerved, the following alterations are ſeen: —It firſt becomes divided into two very diſtinct ſubſtances, the one liquid, ſlightly greeniſh, and called lymph, or ſerum; and the other reddiſh and ſolid, called the fibrous part of the blood. It is this ſeparation of the blood which has cauſed the exiſtence of polypi in the larger veſſels to be credited, becauſe concretions have been found in thoſe veſſels after death. We will ſeparately examine theſe two ſubſtances.

Serum has a yellow colour, inclining to green. Its taſte is ſlightly ſaline. It contains a diſengaged alkali, turns ſyrup of violets green, and hardens in a moderate heat, which is the character of the lymph. Serum diſtilled on a water-bath affords an inſipid phlegm, neither acid nor alkaline, but very readily putrefying. When this phlegm has paſſed over, the reſidue is tranſparent like horn, no longer ſoluble in water, and affording by diſtillation an alkaline phlegm, carbonate of ammoniac, and a fetid blackiſh oil more or leſs thick; the remaining coal in the retort is very voluminous, and very difficult to incinerate; the aſhes afford muriate of ſoda and phoſphate of lime.

Serum eaſily putrefies, and then affords much carbonate of ammoniac.

Serum poured into boiling water coagulates; but it contains a part which is ſoluble in water, to which it communicates a milky colour, and all the properties of milk, according to Bucquet.

Alkalis render the ſerum more fluid, but acids coagulate it. By filtering and evaporating the fluid, a neutral ſalt is obtained, conſiſting of the acid employed, and ſoda. It appears therefore that the lymph is kept in the liquid ſtate by the predominating alkali.

The thickened ſerum affords mephitis by the nitric acid, aſſiſted by a ſlight heat; if the fire be increaſed, nitrous gas is diſengaged: the reſidue affords the oxalic acid, and a portion of malic acid.

Serum is coagulated by alcohol; but the coagulum is ſoluble in water, and in this it differs much from the coagulum formed by acids: this difference depends on the circumſtance that the alcohol ſeizes the water which diluted the ſerum; whereas the acid ſeizes the alkali which diſſolved it.

The clot or fibrous part of the blood likewiſe contains much lymph; but this may be diſengaged by waſhing. The water at the ſame time carries off the colouring matter, which contains much iron: and this coagulated part, when well waſhed, forms a fibrous white ſubſtance void of ſmell; which, diſtilled on the water-bath, affords an inſipid phlegm, eaſily ſuſceptible of putrefaction. The reſidue becomes very dry, even by a gentle heat; when ſuddenly expoſed to a conſiderable heat, it ſhrinks up like parchment; but when diſtilled in a retort it affords an alkaline phlegm, carbonate of ammoniac, oil, &c. The coal, which is leſs voluminous and lighter than that of lymph, affords the phoſphate of lime by incineration.

The fibrous part putrefies with conſiderable quickneſs, and affords much ammoniac.

The alkalis do not diſſolve it, but acids combine with it. The nitric acid diſengages much nitrogene, and afterwards diſſolves it with efferveſcence, and diſengagement of nitrous gas. The reſidue affords oxalic acid, and a ſmall quantity of the malic acid.

This fibrous ſubſtance is of the nature of the muſcular fibre, which cauſed Bordeu to call the blood fluid fleſh: and long before the time of this celebrated phyſician, Paul Zacchia aſſerted that "caro nihil aliud eſt quam ſanguis concretus" (Queſt. Legalis, p. 239). This fibrous matter is more animalized than the lymph; and it appears to be prepared by the very act of circulation to concur in augmenting the parts of the human body.

Blood contains much iron. The experiments of Menghini, Bucquet, and Lorry, prove that this metal is capable of paſſing into the blood by the firſt paſſages, ſince patients who are under a courſe of martial medicine void it by the way of urine. When the coagulated part of the blood has been waſhed, if that part which has retained the colouring matter be burned, and the coal be lixiviated, the reſidue of this lixivium is in the ſtate of ſaffron of mars, of a fine colour, and uſually obedient to the magnet.

The colour of blood has been attributed to iron; and it is very true that the colour appears to be entirely formed of it, for there exiſts no veſtige of this metal in the waſhed and diſcoloured coagulum; but as, on the other hand, the blood does not become coloured without the concourſe of air, and as oxigene alone is abſorbed in reſpiration, it appears that the colour is owing to iron calcined by the pure air, and reduced to the ſtate of red oxide.

From this manner of conceiving the phenomenon, we may perceive why animal ſubſtances are ſo advantageous in aſſiſting and facilitating the red dye, and why theſe ſubſtances take colours more eaſily.

CHAP. IV.

Concerning Fat.

FAT is a condenſed inflammable juice contained in the cellular membrane: its colour is uſually white, but ſometimes yellow; its taſte inſipid; and its conſiſtence more or leſs firm, in the various ſpecies of animals. In cetaceous and other fiſh, it is nearly fluid; in carnivorous animals the fat is more fluid than in frugivorous animals, according to Mr. De Fourcroy. In the ſame animal it is more ſolid near the kidneys, and under the ſkin, than in the vicinity of the moveable viſcera; as the animal grows old, the fat becomes yellow, and more ſolid. Conſult De Fourcroy. To obtain fat in a ſtate of purity, it is cut into ſmall pieces; the membranes and ſmaller veſſels are ſeparated; it is waſhed, then fuſed with a ſmall quantity of water, and kept in fuſion till all the water is evaporated. This laſt fluid which floats above it, boils; and when the ebullition ceaſes, it is a proof that all the water is diſſipated.

Fat has the greateſt analogy with oils. Like them it is not miſcible with water; it forms ſoaps with alkalis; and burns in the open air, by the contact of an ignited ſubſtance, at a ſufficient heat.

Neumann treated the fat of the gooſe, of the hog, of the ſheep, and of the ox, in a glaſs retort by a graduated fire. He obtained phlegm, an empyreumatic and browniſh oil, and a brilliant coal. He concludes from his analyſis that there is little difference between fats; and that that of the ox appears only to contain a little more earthy matter. This very imperfect analyſis throws no light on the nature of fat; and we are indebted to Meſſrs. Segner and Crell for experiments of a much more intereſting kind. We ſhall relate the chief.

1. Beef ſuet diſtilled on the water-bath, in a glaſs retort, affords oil and phlegm; it forms ſoaps with potaſh: the reddiſh phlegm has an acid taſte; effervesces with alkali, without reddening the ſyrup of violets, which aſſumes a brown colour by this mixture.

2. The marrow of beef affords the ſame products, excepting that a ſubſtance firſt paſſes over of the conſiſtence of butter. The phlegm has no ſmell when cold. Fixed alkali occaſions a weak effervefcence.

M. Crell has inſtructed us in the means of obtaining a peculiar acid from fat, which is at preſent diſtinguiſhed by the name of the Sebacic Acid.

He at firſt attempted to concentrate this acid by diſtilling off the phlegm ; but this did not ſucceed, for the liquid in the receiver was as acid as that in the retort. He then ſaturated all the acid with potaſh, and obtained a browniſh ſalt by evaporation, which he fuſed in a crucible, to burn the oil which contaminated it. This ſalt, by ſolution and evaporation, afforded a foliated ſalt. He poured four ounces of ſulphuric acid upon ten ounces of the ſalt, and diſtilled by a very gentle fire. The ſebacic acid paſſed over in the form of a greyiſh vapour; and half an ounce, very fuming and acrid, was found in the receiver. Crell obſerves that, in order to ſucceed in this operation, the ſalt muſt be kept a long time in fuſion, without which the acid would be mixed with oil, which weakens its virtue.

By diſtillation of fat in a copper alembic, Mr. Crell obtained the pure acid. But the fire neceſſary for this purpoſe alters the veſſel, cauſes the tin to run off, and the acid itſelf becomes charged with copper.

It has long been known that the alkalis form a kind of ſoap with animal fat. Mr.

Crell, by treating this ſoap with a ſolution of alum, ſeparated the oil, and obtained the ſebate of potaſh by evaporation: the ſulphuric acid afterwards diſtilled from this ſalt, decompoſes it; and by this means the ſebacic acid is ſeparated.

Mr. De Morveau melted ſuet in an iron pot; and to this he added pulverized quicklime, taking care to ſtir it continually at the commencement; at the end of the operation, a conſiderable heat was applied, taking care to raiſe the veſſels, in order to avoid expoſure to the vapours. When the whole was cold, it was found that the ſuet had no longer the ſame ſolidity. This was boiled in a large quantity of water; and the lixivium, after filtration, afforded a brown acrid ſalt, which is the ſebate of lime. This ſalt is ſoluble in water, but would require too much time to purify it by repeated cryſtallizations. This purpoſe is more eaſily anſwered by expoſing it to a degree of heat capable of burning the oil; after which, a ſingle ſolution is ſufficient to purify it. It leaves its oil upon the filtre in the ſtate of coal; and nothing more is then neceſſary than to evaporate it.

The ſolution uſually contains a ſmall quantity of quicklime, which may be precipitated by the carbonic acid. This ſalt, treated in the ſame manner as the ſebate of potaſh, affords the ſebacic acid.

This acid exiſts ready formed in ſuet: two pounds afforded ſomewhat more than ſeven ounces to Crell. It exiſts ready formed in the fat, ſince earths and alkalis diſengage it.

It has the greateſt affinity with the muriatic acid, as it forms with potaſh a ſalt which melts in the fire without being decompoſed: it acts powerfully on gold, when mixed with nitric acid; it precipitates ſilver from the nitrate of ſilver; it forms a ſublimate with mercury, and the ſolution of this ſublimate is not rendered turbid by the muriate of ſoda. But though this acid approaches the muriatic in ſeveral reſpects, it differs from it in others, and hitherto ſeems to be nothing but a modification of that acid. With ſoda, it forms cryſtals in needles, and a cryſtallized ſalt with lime. It decompoſes common ſalt, &c.

Mr. Crell obtained the acid of fat by diſtillation from the butter of cacao. Spermaceti likewiſe affords it.

The properties of this acid are the following:

It reddens blue vegetable colours.

It aſſumes a yellow colour by fire, and leaves a reſidue, which announces a partial decompoſition.

ſition. From this circumſtance, Mr. Crell conſiders it as occupying the middle ſpace between the vegetable acids which are deſtroyed by fire, and the mineral which receive no alteration. Its exiſtence in the butter of cacao, and in fats, is favourable to the notion of Crell on this ſubject.

It attacks the carbonates of lime and alkali with effervеſcence, and with them forms ſalts which Bergmann finds to be very ſimilar to the acetites with the ſame baſis.

This acid, as Mr. De Morveau obſerves, ſeems to have ſome action upon glaſs. Mr. Crell having digeſted it ſeveral times upon gold, always obtained a precipitate of white earth, which was not lime, but which he preſumes to have been carried up in the diſtillation, and could only ariſe from the retort itſelf.

This acid does not perceptibly act on gold; but it attacks the oxide, and forms a cryſtallizable ſalt, as it does likewiſe with the precipitates of platina.

It unites with mercury and with ſilver; yielding the latter to the muriatic acid, but not the former: it takes both from the ſulphuric acid, lead from the nitric and acetous acids, and tin from the nitro-muriatic acid.

It attacks neither biſmuth, cobalt, nor nickel.

It does not decompoſe the ſulphates of copper, of iron, or of zinc; nor the nitrates of arſenic, manganeſe, zinc, &c.

It reduces the oxide of arſenic by diſtillation. Crell formed a ſebacic ether.

From this analyſis it appears that fat is a kind of oil or butter rendered concrete by an acid.

Its uſes are—1. To keep up the heat of the body, and defend the viſcera from the impreſſion of external cold. 2. To ſerve as nouriſhment or ſupport for the animal on the occaſions of want, ſickneſs, &c.

CHAP. V.

Concerning the Bile.

THE Bile is one of thoſe humours which it is eſſential to know, on account of the influence and effect it has both in the ſtates of health and diſorder. We ſhall even ſee that its analyſis is ſufficiently perfect to afford inſtruction in an infinity of caſes.

This humour is ſeparated in a large viſcus of the lower belly, called the Liver; it is afterwards depoſited in a bladder, or reſervoir, called the Gall Bladder; from which it is conveyed into the duodenum by a particular channel.

The bile is glutinous, or imperfectly fluid, like oil; of a very bitter taſte; a green colour, inclining to yellow; and froths by agitation like the ſolution of ſoap.

If it be diſtilled on the water-bath, it affords a phlegm, which is neither acid nor alkaline, but putrefies. This phlegm, according to the obſervation of Mr. De Fourcroy, often emits a ſmell reſembling that of muſk: bile itſelf has the ſame property, according to the general obſervation of butchers. When the bile has given out all the water it is capable of affording upon the water-bath, the reſidue is a dry extract, which attracts the humidity of the air, is tenacious, pitchy, and ſoluble in water. By diſtillation in a retort, it affords ammoniac, an empyreumatic animal oil, concrete alkali, and inflammable air. The coal is more eaſily incinerated than that we have laſt treated of. It contains iron, carbonate of ſoda, and phoſphate of lime.

All the acids decompoſe bile; and diſengage an oily ſubſtance, which riſes to the top. The ſalts afterwards obtained by evaporation, have ſoda for their baſis; which ſhews that the bile is a true animal ſoap. The oil which is combined with ſoda is analogous to reſins, is ſoluble in ſpirit of wine, &c.

The metallic ſolutions decompoſe bile by double affinity, and produce metallic ſoaps.

Bile unites with oils, and cleans ſtuffs in the ſame manner as ſoap.

Bile is ſoluble in alcohol, which ſeparates the albuminous principle. It is this laſt ſubſtance which renders bile coagulable by fire and by acids; and it is this likewiſe which haſtens its putrefaction.

The conſtituent principles of bile are, water, a ſpiritus rector, a lymphatic ſubſtance, a reſinous oil, and ſoda. Mr. Cadet has found a ſalt in it, which he thought ſimilar to ſugar of milk; this ſalt is probably no other than that which was diſcovered by Mr. Poulletier.

Bile is therefore a ſoap, reſulting from the combination of ſoda with a matter of the nature of reſins, and a lymphatic ſubſtance, which renders it ſuſceptible of putrefaction and coagulation. This ſubſtance gives the bile the character of animalization, diminiſhes its acridity, and favours its mixture with the other humours. The ſaline part renders the bile more fluid and ſoluble in water; and it is more acrid the more this principle abounds.

The reſinous part differs from vegetable reſins—1. Becauſe theſe do not form ſoap with fixed alkalis. 2. Becauſe they are more acrid and more inflammable. 3. Becauſe the animal reſin melts at the temperature of 40 degrees, and acquires a fluidity ſimilar to that of fat; from which however it differs in not being ſoluble in alcohol, in which reſpect it approaches to ſpermaceti.

The acids which act upon bile in the firſt paſſages, decompoſe it. The greeniſh yellow colour of the excrements of infants at the breaſt, ariſes from a ſimilar decompoſition; and it is the reſinous part which tinges them. From the action of the bile upon acids, we may deduce the effect of theſe remedies when the evacuations are putrid, and the degeneration of the bile is ſeptic. The lymph is then coagulated, and the excrements become harder. This ſhews the reaſon why the excrements of infants are ſo frequently clotted.

When the bile remains a long time in the firſt paſſages, as for example in chronical diſorders, it aſſumes a black colour, becomes thick, acquires the conſiſtence of an unguent, and forms a lining of ſeveral lines in thickneſs in the inteſtinal canal, according to the obſervation of Mr. De Fourcroy. When ſmeared on paper, and dried, it becomes green; diluted with water, it forms a tincture of a yellow green colour, from which a large quantity of black ſcales are precipitated: with alcohol it likewiſe forms a black tincture, and depoſits that laminated brilliant ſalt diſcovered in biliary calculi by Mr. Poulletier de la Salle. This humour, which forms the atra bilis of the ancients, is nothing but the bile rendered thick; and in this caſe the effect of acids, and the danger of irritating ſubſtances, may be eaſily accounted for. This thickening of the bile clogs the viſcera of the lower belly, and produces obſtructions.

Many diſorders are referable to the predominant character of the bile. On this ſubject, the intereſting Memoirs of Mr. De Fourcroy may be conſulted, in the collection of the Royal Society of Medicine for the years 1782 and 1783.

When the bile becomes thick in the gall bladder, it forms the concretions called biliary calculi. Mr. Poulletier has paid great attention to the analyſis of theſe ſtones. He has obſerved that they are ſoluble in ardent ſpirit. When the ſolution is left to itſelf for a certain time, brilliant and light particles are ſeen in it, which Mr. Poulletier found only in the human

man calculi, and which appeared to him to have the greateſt analogy with the ſalt of benzoin.

Mr. Fourcroy has obſerved that the diſcovery of Mr. De la Salle has been confirmed by the Royal Society (of Medicine), which has received ſeveral biliary calculi that appeared to be formed by a ſalt analogous to that which was obſerved by this chemiſt. They conſiſt of maſſes of tranſparent cryſtalline plates, ſimilar to mica or talc. The Society of Medicine poſſeſſes in its collection a gall bladder entirely filled with this ſaline concretion.

We may therefore, as Mr. De Fourcroy obſerves, admit of two kinds of calculi: the one are opake, and are afforded only by the condenſed bile; the others conſiſt of the cryſtals we have deſcribed.

Boerhaave obſerved, long ſince, that the gall bladder of oxen, at the end of the winter, was filled with calculi, but that the freſh paſturage diſſipated theſe concretions.

Soaps have been propoſed as ſolvents for theſe calculi. The Academy of Dijon has publiſhed the ſucceſs of a mixture of eſſence of turpentine and ether. Freſh vegetables, which are ſuch ſovereign remedies in deſtroying theſe concretions, owe their virtue perhaps to the circumſtance that they develop an acid in the ſtomach, as we have obſerved in treating of the gaſtric juice.

The uſe of the bile, in the animal œconomy, conſiſts, no doubt, in dividing thoſe ſubſtances which have undergone a firſt digeſtion in the ſtomach; and in giving efficacy and force to the motion of the inteſtines. When its flux is interrupted, it abounds in the blood, and the whole body becomes of a yellow tinge.

The bile or gall is an excellent vulnerary, externally applied: internally taken, it is a good ſtomachic, and one of the beſt deobſtruents the art of medicine poſſeſſes. This kind of remedies deſerves the preference, as being more analogous to the conſtitution; and bile is a proper medicine when the digeſtion languiſhes, or the viſcera of the lower belly are clogged.

Bile, like other ſoaps, removes ſpots of oil, or other greaſy matter, from ſubſtances to which they are adherent.

CHAP. VI.

Concerning the Soft and White Parts of Animals.

THESE parts are perhaps leſs known than thoſe of which we have juſt treated; but their analyſis is not leſs intereſting: we may even affirm that it is more ſo; becauſe the application of the knowledge we may acquire on this ſubject, will daily preſent itſelf in the commoneſt purpoſes of domeſtic life.

All the parts of animals, whether membranes, tendons, aponeuroſes, cartilages, ligaments, or even the ſkin and horns, contain a mucous ſubſtance very ſoluble in water, but not in alcohol, and known by the name of Jelly. Nothing need be done to obtain it, but to boil theſe animal ſubſtances in water, and concentrate the decoction, until by mere cooling it aſſumes the form of a ſolid tremulous maſs.

Jellies are very common in our kitchens; and the cooks are perfectly well acquainted with the methods of making them, and of giving them ſolidity when the temperature of the atmoſphere is very hot. The jelly of harts-horn is extracted by a ſimilar operation, and afterwards rendered white with the milk of almonds. This kind of food, duly ſcented, is ſerved up at our tables by the name of *blanc manger.* Jellies are in general reſtorative and nouriſhing: that of harts-horn is aſtringent and emollient.

Jellies in general have no ſmell in their natural ſtate, and their taſte is inſipid. By diſtillation they afford an inſipid and inodorous phlegm, which eaſily putrefies. A ſtronger heat cauſes them to ſwell up, become black, and emit a fetid odour, accompanied with white acrid fumes. An alkaline phlegm then paſſes over, ſucceeded by an empyreumatic oil, and a little carbonate of ammoniac. A ſpongy coal remains, which is with difficulty reduced to aſhes, and affords by analyſis muriate of ſoda and phoſphate of lime.

Jelly cannot be kept above a day in the ſummer, or two or three in the winter. When it becomes ſpoiled, white livid ſpots are formed on its ſurface, which ſpeedily extend to the bottom of the pots. A large quantity of nitrogenous, hydrogenous, and carbonic gas is emitted.

Water diſſolves jellies perfectly. Hot water diſſolves a large quantity, as they become conſiſtent only by cooling. Acids likewiſe diſſolve them, and alkalis more eſpecially do.

The nitric acid diſengages nitrogene gas, according to the fine experiments of M. Berthollet.

When jelly has been extracted without long decoction, and has no lymph mixed with it, it then poſſeſſes moſt of the characters of the vegetable jelly: but it is ſeldom obtained without a mixture of lymph; and in this caſe it eſſentially differs from the vegetable jellies, in affording nitrogene gas and ammoniac.

If jelly be concentrated to ſuch a degree as to give it the form of a cake, it is deprived of the property of putrefying; and by this means the dry or portable ſoups are formed, which may be of the greateſt advantage in long voyages. The following is a receipt for preparing theſe cakes:

Calves feet -	4	
Leg of beef -	12	pounds,
Knuckle of veal	3	pounds,
Leg of mutton -	10	pounds,

Theſe are to be boiled in a ſufficient quantity of water, and the ſcum taken off as uſual; after which the ſoup is to be ſeparated from the meat by ſtraining and preſſure. The meat is then to be boiled a ſecond time in other water; and the two decoctions, being added together, muſt be left to cool, in order that the fat may be exactly ſeparated. The ſoup muſt then be clarified with five or ſix whites of eggs, and a ſufficient quantity of common ſalt added. The liquor is then ſtrained through flannel, and evaporated on the water-bath to the conſiſtence of a very thick paſte; after which it is ſpread rather thin upon a ſmooth ſtone, then cut into cakes, and laſtly dried in a ſtove until it becomes brittle: theſe cakes are kept in well cloſed bottles. The ſame proceſs may be uſed to make a portable ſoup of the fleſh of poultry; and aromatic herbs may be uſed as a ſeaſoning, if thought proper.

Theſe tablets or cakes may be kept four or five years. When intended to be uſed, the quantity of half an ounce is put into a large glaſs of boiling water, which is to be covered, and ſet upon hot aſhes for a quarter of an hour, or until the whole is entirely diſſolved. It forms an excellent ſoup, and requires no addition but a ſmall quantity of ſalt.

The cakes of hockiac, which are prepared in China, and are known in France by the name of *colle de peau d'âne*, are made with animal ſubſtances. They are uſed in diſorders of the lungs, in the doſe from half a dram to two drams.

The nature of the ſubſtances made uſe of, and the method of operating, produce ſome difference in theſe products. Old or lean animals afford in general a better glue than the young and fat. For a full account of the art of making glue, conſult *L'Art de faire différentes Eſpèces de Colle, par M. Duhamel de Monceau, de l'Académie des Sciénces.*

1. To make the ſtrong or Engliſh glue, the parings of leather, the ſkins of animals, with the ears of oxen, calves, ſheep, &c. are uſed. Theſe matters are firſt digeſted in water, to penetrate the texture of the ſkins; they are afterwards ſteeped in lime water, taking care to ſtir and agitate them from time to time; they are then laid in a heap for ſome time, afterwards waſhed, and the ſuperabundant water preſſed out by a preſs. Theſe ſkins are then digeſted in water gradually heated to ebullition. The liquor is afterwads poured out, and ſeparated with preſſure. Laſtly, it is thickened by evaporation of the water by heat, and poured on flat poliſhed ſtones, or into moulds, and left to dry and harden.

This glue is brittle. It is ſoftened by heating it with a ſmall quantity of water for uſe, and is applied with a bruſh. Carpenters and cabinet-makers uſe it to faſten pieces of wood together.

2. The glue of Flanders is merely a diminutive of the ſtrong glue. It has not the ſame conſiſtence, and cannot be uſed in glueing wood; it is thinner and more tranſparent than

the former. It is made with a more accurate choice of materials, and with greater care. It is uſed by deſigners. Mouth glue is made of this, to ſtick paper together, by fuſing it again with the addition of a ſmall quantity of water, and four ounces of ſugar-candy, to a pound of the glue.

3. The colle de gand is made with the clippings of white gloves, well ſteeped in water, and boiled: it is likewiſe made with the clippings of parchment. In order that theſe two kinds of glue may be fit for uſe, it is neceſſary that they be of the conſiſtence of a tremulous jelly when cold.*

4. Fiſh-glue, or iſinglaſs, is made of the mucilaginous parts of a large fiſh commonly found in the Ruſſian ſeas. The ſkin, the fins, and the nervous parts, are cut into ſlices, boiled on a ſlow fire to the conſiſtence of jelly, ſpread out to the thickneſs of a ſheet of paper, and formed into cakes or long pieces, ſuch as we receive them from Holland. The ſilk manufacturers, and more eſpecially the ribbon weavers, uſe it to give a luſtre to their goods: it is alſo uſed to ſtiffen gauzes; and to clarify or fine wine, by mixing a ſolution of this ſubſtance

---

* Theſe weaker glues are called ſize by our workmen, who apply the name of Glue to the ſtrong glue only. T.

ſtance with it. Iſinglaſs enters into the compoſition of ſome plaſters. It is excellent to correct acrid humours, and terminate obſtinate venereal diſorders.

Gilders' ſize is made by boiling eel-ſkins in water with a ſmall quantity of lime: the water is ſtrained off, and ſome whites of eggs added. When it is intended to be uſed, it is heated, applied to the ſurface intended to be gilded, and when it is dry the gold leaf is laid on.

5. The glue of ſnails is made by expoſing ſnails to the ſun, and receiving in a glaſs the fluid which flows from them. This liquor is mixed with the juice of milk thiſtle. It is uſed to cement glaſſes together, which are afterwards expoſed to the ſun to dry.

6. To make the glue of parchment, or parchment ſize, two or three pounds of the clippings of parchment are put into a pail of water. Theſe are boiled until half the water is evaporated; after which the whole is ſtrained through a cloth, and left to ſettle.

The glue or ſize uſed in the paper manufactories, to fortify the paper, and to repair its defects, is made with wheat flour diffuſed in boiling water, and ſtrained through a ſieve. This ſize muſt be uſed the following day, and neither ſooner nor later. The paper is afterwards beat with a mallet, ſized a ſecond time, put into the preſs to ſmooth and unite it, and afterwards extended by hammering.

CHAP. VII.

Concerning the Muſcular or Fleſhy Parts.

THE muſcles of animals are formed of longitudinal fibres connected together by the cellular membrane, and impregnated with various humours, in which we find partly thoſe we have already examined ſeparately.

The analyſis of theſe ſubſtances by diſtillation, afforded us little inſtruction reſpecting their nature. The products were, water which eaſily became putrid, alkaline phlegm, empyreumatic oil, carbonate of ammoniac, and a coal which afforded by incineration a ſmall quantity of fixed alkali, and febrifuge ſalt.

The proceſs which ſucceeds the beſt for ſeparately obtaining the various ſubſtances which compoſe muſcles, is the following, which has been pointed out to us by Mr. De Fourcroy.

1. The muſcle is firſt waſhed in cold water: by this means the colouring lymph, and a ſaline

ſubſtance, are taken up. By ſlow evaporation of this water, the lymph coagulates, and may be ſeparated by the filtre; and a continuance of the evaporation affords the ſaline matter.

2. The reſidue of the firſt waſhing is digeſted in alcohol, which diſſolves the extractive matter, and a portion of the ſalt: the extract is ſeparated by the evaporation of the alcohol.

3. The reſidue of theſe firſt operations is to be boiled in water, which takes up the jelly, the fat part, and the remaining ſaline and extractive matters. The fat oil ſwims on the ſurface, and may be taken off.

4. After theſe operations, there remains only a white inſipid fibrous ſubſtance, inſoluble in water; which contracts by heat, like other animal ſubſtances; affords ammoniac, and very fetid oil, by diſtillation. Nitrogene gas is obtained from it by the nitric acid. It poſſeſſes all the characters of the fibrous part of the blood, in which fluid it is formed, to be afterwards depoſited in the muſcles, where it receives the laſt character appropriated to it.

Mr. Thouvenel, to whom we are indebted for intereſting reſearches on this ſubject, has found in fleſh a mucous extractive ſubſtance, ſoluble in water and in alcohol, poſſeſſing a peculiar taſte which jelly has not; and when this ſubſtance is very much concentrated, it aſſumes an acrid and bitter taſte. Fire develops an aromatic flavour in it. This ſubſtance, evaporated to dryneſs, aſſumes a bitter, acrid, and ſaline taſte. It ſwells up upon hot coals, and liquefies; emitting an acid penetrating ſmell, reſembling that of burned ſugar. It attracts the humidity of the air, and forms a ſaline efflorefcence. In a hot atmoſphere it becomes ſour, and putrefies. All theſe characters indicate a reſemblance between this ſubſtance, the ſaponaceous extracts, and the ſaccharine matter of vegetables. Mr. Thouvenel, who has likewiſe analyſed the ſalt obtained by the decoction and ſlow evaporation of fleſh, obtained it ſometimes in the form of down, and ſometimes in that of cryſtals, whoſe figure he could not deſcribe. This ſalt appeared to him to be a phoſphate of potaſh in frugiverous quadrupeds, and a muriate of potaſh in carnivorous reptiles. It is probable, as Mr. De Fourcroy obſerves, that this ſalt is a phoſphate of ſoda or of ammoniac, mixed with the phoſphate of lime. Theſe ſalts are indicated, and even with exceſs of acid, like thoſe of urine, by lime-water and ammoniac, which form white precipitates in the decoction of fleſh.

The moſt abundant part of muſcles, and that which conſtitutes their predominating character, is the fibrous matter. The characters which diſtinguiſh this ſubſtance are—

1. It is not ſoluble in water. 2. It affords more nitrogene gas by the nitric acid than other ſubſtances do. 3. It afterwards affords the oxalic acid, and the malic acid. 4. It putrefies eaſily when moiſtened, and affords much concrete ammoniac by diſtillation.

The other three ſubſtances contained in fleſh, namely the lymph, the jelly, and the fat part, are the ſame ſubſtances concerning which we have already treated under the ſame denominations.

From theſe principles we may give the etiology of the formation of ſoup, and follow the ſucceſſive diſengagement of all the principles we have ſpoken of.

The firſt impreſſion of the fire, when a ſoup is made, is the diſengagement of a conſiderable ſcum, which is taken off until it no longer appears. This ſcum ariſes merely from the diſengagement of the lymph, which coagulates by the heat. It aſſumes, by the impreſſion of the fire, a red colour, which it does not naturally poſſeſs.

At the ſame time the gelatinous part is diſengaged, which remains diſſolved in the ſoup, and congeals only by cooling. It forms on the ſurface of cold ſoup a body more or leſs thick, according to the nature of the ſubſtances, and the age of the animals; for young animals afford a larger quantity than ſuch as are old.

As ſoon as the fleſh is penetrated by heat, flat round drops ariſe, and float at the ſurface of the fluid, in which they are not afterwards diſſolved, but congeal by cooling, and exhibit all the characters of fat.

In proportion as the digeſtion proceeds, the mucous extractive part ſeparates; the ſoup becomes coloured, aſſumes its peculiar odour and taſte; and it is more particularly to this principle that its properties are owing.

The ſalt which is at the ſame time diſſolved takes off the inſipidity of all the before-mentioned principles; and at this period the ſoup is completely made.

According to the nature of the ſeveral principles which are diſengaged, and the order in which they appear, it is evident that the management of the fire is not a matter of indifference. If the ebullition be haſtened, and a proper time be not allowed for the diſengagement of the mucous extractive matter, the three inodorous and inſipid principles are obtained;

and this is obſerved in ſoups made by cooks who are haſtened, or have not time allowed to pay a due attention to their work. When, on the contrary, the digeſtion is made over a ſlow fire, the principles ſeparate one after the other, in order; the ſkimming is more accurately performed; the aromatic flavour which is diſengaged combines more intimately, and the ſoup is of an excellent flavour. Theſe are the ſoups of the good women who perform better with a ſmall quantity of meat, than profeſſed cooks with their uſual prodigality; and in this caſe we may ſay that the form is of more value than the ſubſtance.

The heat muſt not be applied too long; for the great evaporation, by concentrating the principle of ſmell and taſte, at the ſame time with the ſalt, renders them acrid and bitter.

CHAP. VIII.

Concerning Urine.

URINE is an excrementitious humour of the body: and it is one of the fluids of which it is of the greateſt importance to poſſeſs an accurate knowledge; becauſe the practical phyſician may derive the greateſt advantage from information of this nature. It is known to what a degree of extravagance the marvellous pretenſions of this kind have been carried. The delirium has proceeded to ſuch a height, as even to pretend to aſcertain from the urine, not only the nature of the diſorder, and the character of the patient, but likewiſe the ſex and condition.

The true phyſician has never given into this exceſs: but he has always derived aſſiſtance, in his practice, from the characters exhibited by the urine; and this is the humour from which he may draw the moſt ſatisfactory indications. It carries out, as we may ſay, the internal character; and a phyſician who knows how to form a judgment upon its properties, may deduce the moſt inſtructive conſequences from it. Monro, in his Treatiſe of Comparative Anatomy, has deſcribed the organs which, in birds, ſupply the place of the kidneys: they are placed near the vertebral column; and communicate, by two ducts, to the vicinity of the anus. He affirms that the urine of birds is that whitiſh ſubſtance which almoſt always accompanies the excrements.

Chemical analyſis ought to enlighten the phyſician in his reſearches concerning the urine.

The nature of the principles it carries off in certain circumſtances, affords vaſt information reſpecting the predominant principle in the fluids of the human body. Its various ſtates ſhew the diſpoſition of the conſtitution. Perſons of a very irritable habit have the urine of a lighter colour than others; gouty perſons evacuate turbid urine; and it has been obſerved that, when the bones become ſoft, the urine carries off the phoſphate of lime, which conſtitutes their baſis; inſtances of which were obſerved in the perſons of Mrs. Supiot, the widow Melin, &c. The various ſtates of any diſorder are always pointed out by the ſtate of the urine; and the truly practical phyſician will there obſerve ſigns of crudity and concoction which will direct his proceedings.

Urine is likewiſe an humour intereſting to be known on account of the various uſes to which it is applied in the arts. It was from this ſubſtance alone that phoſphorus was, for a long time, extracted; it is to this fluid that we owe the development of the blue colour of turnſole, and the violet of archil; it may be ſucceſsfully employed in forming artificial nitre-beds; it powerfully contributes to the formation of ſal ammoniac; it may be uſed to prepare the alkali in the manufacture of Pruſſian blue; and, in a word, it may be applied in all the operations wherein the concurrence of an animal humour is required.

Urine, in its natural ſtate, is tranſparent, of a citron yellow colour, a peculiar ſmell, and a ſaline taſte.

It is more or leſs abundant, according to the ſeaſons, and the ſtate of the individual. It is ſufficient to obſerve, on this ſubject, that tranſpiration, and more particularly perſpiration or ſweat, ſupply the place of the ſecretion of urine; and that conſequently, when the tranſpiration is great, the urine is not abundant.

Phyſicians diſtinguiſh two kinds of urine. The one is emitted one or two hours after drinking; this is aqueous, contains ſcarcely any ſalts, and has neither colour nor ſmell: it is this which is evacuated ſo plentifully during a courſe of mineral waters. The other is not evacuated until after the functions of ſanguification are finiſhed; and may be called Fæces Sanguinis. This has all the characters we have enumerated and aſſigned to urine. It is carried by the arteries into the kidneys, where it is ſeparated, and poured into the receptacles of theſe organs, whence it paſſes, by the ureters, into the bladder; where it remains a longer or ſhorter time according to the habitude of the perſon, the nature of the urine, the irritability or magnitude of the bladder itſelf.

The urine has been long conſidered as an alkaline fluid; but in our time it has been proved to contain an exceſs of acid. It appears from the experiments of M. Berthollet—1. That this acid is of the nature of the phoſphoric acid. 2. That the urine of gouty perſons contains leſs of this acid; whence he conjectures, with reaſon, that this acid retained in the blood, and conveyed into the articulations, produces an irritation, and conſequently a flux of humours, which cauſe pain, and ſwelling.

The analyſis of urine by diſtillation has been accurately made by various chemiſts, but more eſpecially by Rouelle the younger. Much phlegm is obtained, which putrefies with the greateſt facility, and affords ammoniac by its putrefaction, though it does not itſelf contain that ſubſtance. At the ſame time a ſubſtance is precipitated of an earthy appearance, but which in reality is a true phoſphate of urine. It is this ſame ſalt which forms the ſediment of urine, which is obſerved by expoſing it to cold during the winter, even though the urine be of a perſon in perfect health. When urine has, by a ſufficient evaporation, acquired the conſiſtence of ſyrup, it need only be expoſed, in a cool place, to obtain cryſtals, in which analyſis has proved the exiſtence of the phoſphates of ſoda and of ammoniac. This precipitate of cryſtals has been diſtinguiſhed by the name of fuſible ſalt, native ſalt, microcoſmic ſalt. Urine may be deprived of all ſaline matter by repeated ſolutions, filtrations, and evaporations; the matter which adheres to theſe cryſtals, and of which they may be cleared by theſe operations, is ſoluble, partly in alcohol, and partly in water. The ſaponaceous ſubſtance, or that which is ſoluble in alcohol, is capable of cryſtallization, dries difficultly, and affords by diſtillation a ſmall quantity of oil, of carbonate of ammoniac, of muriate of ammoniac, and the reſidue converts ſyrup of violets to a green. The extractive principle is eaſily dried, and exhibits the ſame phenomena in diſtillation as animal ſubſtances. See Rouelle.

The phenomena exhibited by the ſpontaneous decompoſition of urine are very intereſting to be known; on which ſubject an excellent memoir of Mr. Halle, in the volume of the Society of Medicine for 1779, may be conſulted. Urine left to itſelf ſoon loſes its ſmell, which is ſucceeded by a ſmell of ammoniac, which is likewiſe diſſipated in its turn. The colour becomes browniſh, and the ſmell fetid and nauſeous. We are indebted to Mr. Rouelle for a valuable obſervation—that crude urine, *urina potûs*, preſents very different phenomena; and that it becomes covered with mouldineſs, like the expreſſed juices of vegetables. Putrefied urine has much leſs acid in the diſengaged ſtate than when it is freſh.

The fixed alkalis and lime diſengage much ammoniac from urine, by decompoſing the phoſphate of ammoniac.

The acids deſtroy the ſmell of urine by combining with the ammoniac, which is the principal vehicle of that ſmell.

We may therefore conſider urine, in its natural ſtate, as water holding in ſolution matters purely extractive, and phoſphoric or muriatic ſalts. Theſe phoſphoric ſalts have lime, ammoniac, or ſoda, for their baſis: we ſhall take a ſlight view of each in particular.

That which is called fuſible ſalt, is nothing but a mixture of all the ſalts contained in urine, clogged with the extractive principle. All the ancient chemiſts adviſed evaporation, and repeated filtration, to clear them from this animal extract; but Meſſrs. Rouelle and the Duke de Chaulnes have obſerved, that great part of the ſalt is diſengaged and diſſipated by theſe operations to ſuch a degree, that three-fourths are loſt. To avoid moſt of this loſs, the Duke de Chaulnes adviſes ſolution, filtration, and cooling in well-cloſed veſſels. Two ſtrata of ſalt are then obtained; the upper of which appears to have the form of ſquare tables, wherein Rouelle obſerved tetrahedral priſms flattened with dihedral ſummits. This is the phoſphate of ſoda: and beneath this lies another ſalt cryſtallized in regular tetrahedral priſms, and is the phoſphate of ammoniac.

1. The phoſphate of ammoniac uſually exhibits the form of a very compreſſed tetrahedral rhomboïdal priſm: but this form varies much; and the mixtures of the phoſphate or muriate of ſoda cauſe an infinity of modifications in it.

The taſte of this ſalt is cool, afterwards urinous, bitter, and pungent.

This ſalt ſwells up upon the coals, emits a ſtrong ſmell of ammoniac, and melts by the blow-pipe into a very fixed and very fuſible glaſs.

It is ſoluble in water. Five parts of cold water, at ten degrees of Reaumur, diſſolved only one of this ſalt; but at the temperature of ſixty degrees this ſalt is decompoſed, and a portion of its acid is volatilized.

It ſerves as a flux to all the earths; but in this caſe its alkali is diſengaged, and the phoſphoric acid unites with the earth, as I find by experiment. Bergman propoſed it as a flux. The fixed alkalis and lime-water diſengage the ammoniac.

When this ſalt is heated with charcoal, it affords phoſphorus.

2. The phoſphate of ſoda was made known in 1740 by Haupt, under the name of ſal admirabile perlatum. Hellot before him, and Pott ſeventeen years after him, took it for ſelenite. Margraaf gave an accurate deſcription of it in his Memoirs, in 1745; and Rouelle the younger deſcribed it at full length in 1776, under the name of fuſible ſalt with baſe of natrum. All agree that it differs from the preceding in not affording phoſphorus with charcoal.

According to Rouelle, its cryſtals are flattened irregular tetrahedral priſms, with dihedral ſummits. The four ſides of the priſm are two irregular alternate pentagons, and two long rhombi truncated ſlopewiſe.

When expoſed to heat it fuſes, and affords a glaſs which becomes opake by cooling.

It is ſoluble in diſtilled water, and the ſolution turns ſyrup of violets green.

It does not afford phoſphorus with charcoal.

Lime diſengages the ſoda. It may even be obtained in a cauſtic ſtate, if the precipitation be effected by lime-water.

The mineral acids, or even diſtilled vinegar, decompoſe it by ſeizing its alkali. Mr. Prouſt, to whom we are indebted for all the accurate information we poſſeſs concerning theſe ſubſtances, was of opinion, that the baſe to which the ſoda adhered was not the phoſphoric acid, but a very ſingular ſalt, whoſe properties greatly reſembled thoſe of the acid of borax. He found this ſalt in the mother water, after having decompoſed the phoſphate of ſoda by the acetous acid, and obtained the acetite of ſoda by cryſtallization. He obtained this ſame ſalt by diſſolving and evaporating the reſidue of the diſtillation of phoſphorus. One ounce of phoſphoric glaſs contains five or ſix drams. This ſalt was characterized by the following properties:

1. It cryſtallizes in parallelograms.

2. Its taſte is alkaline, and it turns ſyrup of violets green.

3. It ſwells up in the fire, reddens and melts.

4. It effloreſces in the air. This may not take place when the phoſphoric acid has not been ſufficiently decompoſed by the diſtillation to leave the alkali diſengaged, as I have obſerved.

5. Boiling water diſſolves ſix gros per ounce.

6. It aſſiſts the vitrification of earths, and forms a perfect glaſs with ſilex.

7. It decompoſes nitre and marine ſalt, and ſeparates their acids.

8. It is inſoluble in alcohol.

Mr. Klaproth has publiſhed in Crell's Journal an analyſis of the fuſible ſalt, in which he has ſhewn that the pearly ſalt, or ſalt of Prouſt, is merely the phoſphate of ſoda. To prove this, nothing more need to be done than to diſſolve this ſalt in water, and to add a ſolution of nitrate of lime. The nitric acid ſeizes the ſoda, and the phoſphoric acid is precipitated with the lime. The phoſphoric acid may afterwards be ſeparated by means of the ſulphuric acid.

If the phoſphoric acid obtained by the ſlow combuſtion of phoſphorus be ſaturated with ſoda ſlightly in exceſs, the fuſible ſalt is formed; if this exceſs be taken up by vinegar, or if more phoſphoric acid be added, the ſubſtance deſcribed by Prouſt is formed.

The phoſphate of ſoda is not decompoſable by charcoal; and it is at preſent clearly ſeen why the fuſible ſalt affords but little phoſphorus; and why Kunckel, Margraaf, and others recommended a mixture of the muriate of lead: for by this means the phoſphate of lead was formed, which permits the decompoſition of the phoſphoric acid, and affords phoſphorus.

Concering the Calculus of the Bladder.

Paracelſus made ſome reſearches concerning the calculus of the bladder, which he calls duelech. He conſiders it as a ſubſtance intermediate between tartar and ſtone, and thinks that its formation is owing to the modification of an animal reſin: he ſuppoſes it to be abſolutely ſimilar to the matter of the gout.

Vanhelmont does not admit of this analogy; and conſiders the calculus as an animal coagulum produced by the ſalts of urine, and a volatile earthy ſpirit. Boyle found this calculus to be compoſed of oil and volatile ſalt. Boerhaave ſuppoſed it to conſiſt of a ſubtle earth, intimately united with alkaline volatile ſalts. Hales has obſerved that a calculus of the weight of two hundred and thirty grains afforded ſix hundred and forty-five times its volume of air, and that there remained only a calx of the weight of forty-nine grains.

Independent of this chemical information, ſome phyſicians, ſuch as Alſton, De Haen, Vogel, Meckel, &c. had obſerved the ſolvent power of ſoap, lime-water, and alkalis.

But we poſſeſſed no accurate ideas on this ſubject until it was ſeriouſly taken up by Scheele and Bergman. The bezoar of the bladder is formed for the moſt part of a peculiar concrete acid, which M. De Morveau calls the Lithiaſic Acid. (The Encyclopédie Méthodique may be conſulted, from which the preſent article is an extract.)

The calculus is partly ſoluble in boiling water. The lixivium reddens the tincture of turnſole; and by cooling depoſits moſt of what it had diſſolved. The cryſtals thus ſeparated are the concrete lithiaſic acid.

Scheele has likewiſe obſerved—1. That the ſulphuric acid does not diſſolve the calculus unleſs aſſiſted by heat, and that it is then converted into the ſtate of ſulphureous acid. 2. That the muriatic acid has no action upon it. 3. That the nitric acid diſſolves it with effervеſcence, and diſengages nitrous gas and carbonic acid. This ſolution is red; it contains a diſengaged acid, and tinges the ſkin of a red colour. This ſolution is not precipitated by the muriate of barytes, nor rendered turbid by the oxalic acid. 4. That the calculus was not attacked by the carbonate of potaſh; but that the cauſtic alkali diſſolved it, as well as the volatile alkali. 5. That one thouſand grains of lime-water diſſolved 5,37 by mere digeſtion, and that it was again precipitated by acids.

6. That all urine, even that of infants, held a ſmall quantity of the matter of calculus in ſolution; which may perhaps be the cauſe that, when this matter finds a nucleus in the bladder, it more eaſily incruſts it. I have ſeen a calculus with a large plum ſtone in its centre. 7. That the brick-coloured depoſition from the urine in fevers, is of the nature of the calculi.

Theſe experiments exhibit ſeveral important conſequences with regard to the compoſition of the calculus, and the properties of the lithic acid.

The calculus contains a ſmall quantity of ammoniac. The coaly reſidue of the combuſtion indicates an animal ſubſtance of the nature of jelly. The celebrated Scheele did not find it to contain a particle of calcareous earth; but Bergman precipitated a true ſulphate of lime, by pouring the ſulphuric acid into the nitrous ſolution of the calculus. He admits that the lime is very ſmall in quantity, as it rarely exceeds the two-hundredth part of the entire weight. The ſame chemiſt has detected a white ſpongy ſubſtance, not ſoluble in water, nor attacked by ſpirit of wine, or acids, or alkalis; which at laſt affords a coal of difficult incineration, and which the nitric acid does not diſſolve, even in the ſtate of aſhes; but this matter exiſts in ſo ſmall a quantity, that he could not procure enough to examine it. The calculus is not therefore analogous to bones in its nature; neither is it a phoſphate of lime, as has been pretended These are the reſults of the chemiſts of the north; but I muſt obſerve that, after having decompoſed many calculi by the cauſtic alkali, I have precipitated lime, and formed phoſphates of potaſh.

Some phyſicians, ſuch as Sydenham, Cheyne, Murray, &c. have thought that the arthritic concretions were of the ſame nature as the calculus. The uſe which Boerhaave made of alkalis in the gout; the virtues admitted by Fred. Hoffmann in the thermal waters of Carlſbad, which contain ſoda, with an exceſs of carbonic acid; the authority of Springsfeld, who aſſerts that the calculus is very ſpeedily diſſolved in theſe waters, even tn the urine of thoſe who drink them; the ſucceſs of lime-water, uſed by Alſton in the gout—all conſpire to give ſome credit to the opinion of theſe early phyſicians. But the following experiments do not agree with this notion.

Vanſwieten affirms that the arthritic concretion never acquires the hardneſs of the calculus. Pinelli (Philoſ. Tranſ.) diſtilled in a retort three ounces of the arthritic matter collected from the articulations of ſeveral gouty perſons; and he obtained ammoniac, with ſome drops of oil, the reſidue weighing two gros. This reſidue, which was ſoluble in the muriatic, ſulphuric, and acetous acids, was not attacked by volatile alkali. An obſervation of Mr. Rœring was publiſhed in the Memoirs of the Academy of Stockholm for 1783, which aſcertains that the concretions expectorated by an old man ſubject to the gout, were found to be of the nature of bone, or phoſphate of lime. But one of the neweſt and moſt important facts is that of Watſon, in the Medical Communications of London, vol. i. 1784. He concludes, from the examination of the arthritic concretions of a gouty body, that this ſubſtance is very different from the matter of the calculus, ſince it is ſoluble in the ſynovia, and eaſily mixes with oil and water, which the calculus does not.

It follows from our obſervations on the lithic acid, that this acid is concrete, and ſparingly ſoluble in water; that it is decompoſed, and partly ſublimed by diſtillation. This acid decompoſes the nitric acid, unites with earths, alkalis, and metallic oxides. It yields its baſes to the weakeſt vegetable acids, not excepting the carbonic.

CHAP. IX.

Concerning Phoſphorus.

PHOSPHORUS is one of the moſt aſtoniſhing products of chemiſtry. It is pretended that traces of the knowledge of this ſubſtance exiſt in the writings of the earlieſt chemiſts: but the moſt poſitive information we poſſeſs on this ſubject is found in the hiſtory given by Leibnitz, in the Melanges de Berlin for 1710. He gives the diſcovery to Brandt, a chemiſt of Hamburg, who during a courſe of experiments upon urine, with a view of extracting a fluid proper to convert ſilver into gold, diſcovered phoſphorus in the year 1667. He communicated his diſcovery to Kraft, who ſhewed it to Leibnitz; and being afterwards in England, he communicated it to Boyle*. Leibnitz cauſed the firſt inventor to be introduced to the Duke of Hanover, before whom he performed the whole operation; and a ſpecimen of the phoſphorus was ſent to Huygens, who ſhewed it to the Academy of Sciences at Paris.

---

* As Boyle communicated the proceſs for making phoſphorus to the Royal Society as a diſcovery of his own, and it is entered as ſuch in the Philoſophical Tranſactions, I cannot avoid animadverting on this impeachment of his integrity, which is copied from one chemical book into another. It is grounded on no better foundation than the aſſertion of Kraft,

It is ſaid that Kunckel had aſſociated himſelf with Kraft to purchaſe the proceſs from Brandt. But Kunckel having been deceived by Kraft, who kept the ſecret to himſelf, knowing that urine was made uſe of, ſet to work, and diſcovered a proceſs for making the ſubſtance; and it is this which led chemiſts to call it by the name of Kunckel's Phoſphorus.

Though the proceſs was rendered public,

Kraft, a dealer in ſecrets, who, after having deceived his friend Kunckel, aſſociated with him for the purchaſe of this ſecret. I might inſiſt, in defence of the candour and otherwiſe unimpeached integrity of Boyle, that his aſſertion ought infinitely to outweigh that of the other. Not to inſiſt, however, upon this, it may be noticed that this new and famous product was known to have been extracted from urine; that Kunckel is univerſally admitted as the diſcoverer, from his having formed it upon no fuller information than this; that Boyle might with equal probability be admitted to have diſcovered it in the ſame manner, and upon information equally ſlight; and that the probability of this is rendered incomparably greater, by the conſideration, that none of theſe chemiſts made any complicated experiments, but merely applied the force of fire to urine until this product at laſt came over. T.

Kunckel. and a German called Godefred Hatwith*, were the only perſons who prepared phoſphorus for a long time. It was not till the year 1737, that it was made in the laboratory of the Royal Garden at Paris. A foreigner executed this operation in the preſence of Meſſrs. Hellot, Du Fay, Geoffroi, and Du Hamel. An account of the operation may be ſeen in the volume of the Academy for 1737. Hellot has collected all the eſſential circumſtances. Margraaf, in the year 1743, publiſhed a new and more eaſy method, which has been followed until Scheele and Gahn taught us to obtain it from bones.

The proceſs of Margraaf conſiſts in mixing the muriate of lead, which remains after the diſtillation of four pounds of minium and two of ſal ammoniac, with ten pounds of the extract of urine of the conſiſtence of honey. Half a pound of charcoal in powder is added; the mixture is dried in an iron pot until it is reduced to a black powder. This powder is to be put into a retort; and the volatile alkali, the fetid oil, and the ſal ammoniac, diſtilled off. The reſidue contains the phoſphorus. It is aſſayed by throwing a ſmall quantity on hot coals: if it emits a ſmell of garlic, and a phoſphoric flame, it is to be put into a good earthen retort, and diſtilled. Much more phoſphorus is obtained by this than by the old proceſs; and this depends on the addition of the muriate of lead by Margraaf, which decompoſes the phoſphate of ſoda, forming a phoſphate of lead, which affords phoſphorus; whereas the phoſphate of ſoda is not decompoſable by charcoal. The famous chemiſt of Berlin has likewiſe proved that it was the fuſible ſalt of urine which affords the phoſphorus.

---

* Spelled Hanckwitz by moſt authors. He was inſtructed by Boyle. T.

Mr. Gahn publiſhed, in the year 1769, that the earth of calcined bones conſiſted of lime united with the acid of urine; but Scheele was the firſt to prove that by decompoſing this ſalt of bones by the nitric and ſulphuric acids, evaporating the reſidue in which the phoſphoric acid exiſts in a diſengaged ſtate, and diſtilling the extract with powder of charcoal, phoſphorus is obtained. Theſe circumſtances, related by Bergmann himſelf in his notes to the Chemiſtry of Scheffer, attribute to Scheele the diſcovery of extracting phoſphorus from bones. It was not until the year 1775 that the proceſs was publiſhed in the Gazette Salutaire de Bouillon. Additions and improvements have been ſucceſſively made in this proceſs, of which accounts may be ſeen in the Dictionnaire Encyclopedique.

The proceſs which has moſt conſtantly ſucceeded with me, is the following:

The hardeſt bones are ſelected and burned. By this combuſtion the external part becomes white, while the internal part is blackiſh.

Theſe burned bones muſt then be pulverized, and put into a turine, or in a round hooped wooden veſſel. Half their weight of oil of vitriol is then to be poured on, and conſtantly ſtirred. During the agitation a conſiderable heat is excited. The mixture muſt be left in digeſtion for two or three days; after which, water muſt be gradually added, and ſtirred. I digeſt this laſt mixture upon the fire, in order to increaſe the ſolvent power of the water.

The water of the lixivium is then to be evaporated in veſſels of ſtone ware, ſilver, or copper. Mr. Pelletier recommends this laſt metal; becauſe, according to him, the phoſphoric acid does not attack copper. The evaporation muſt be carried to dryneſs; more boiling water muſt be poured on the reſidue; and this waſhing muſt be continued until the matter be exhauſted, which may be known by the water being no longer tinged yellow. All theſe waters are to be evaporated, and afford an extract.

To ſeparate the ſulphate of lime, the extract muſt be diſſolved in the leaſt poſſible quantity of water, then filtered, and the ſalt remains on the filtre. This extract may be mixed with powder of charcoal, and diſtilled: but I prefer converting it into animal glaſs; for which purpoſe I put the extract into a large crucible, and urge the fire. It ſwells up at firſt, but at laſt ſettles; and at that inſtant the glaſs is made. This glaſs is white, of a milky colour. Becher was perfectly acquainted with it; but concealed his proceſs, on account of the abuſes which, according to him, might be made of it—*propter varios abuſus.* He tells us, in proper terms, *homo vitrum eſt, et in vitrum redigi poteſt; ſicut et omnia animalia.* He regrets that the Scythians, who drank out of diſguſting ſculls, were not acquainted with the art of converting them into glaſs. He ſhews that it would be poſſible to form a ſeries of one's anceſtors in glaſs, in the ſame manner as we poſſeſs them in painting, &c.

I obſerved once, to my great aſtoniſhment, that the phoſphoric glaſs I had juſt made, emitted very ſtrong electric ſparks: theſe flew to the hand at the diſtance of two inches. I exhibited this phenomenon to my audience of pupils. This glaſs loſt the property in two or three days, though preſerved in a capſule of common glaſs.

It ſometimes happens that this glaſs is deliqueſcent, but it is then acid; and this circum-

ſtance

ſtance ariſes from too large a quantity of ſulphuric acid, or from this acid not having been ſaturated by a digeſtion of ſufficient continuance.

I have likewiſe obtained glaſs of the colour of turquoiſe, when I performed the evaporation in copper veſſels.

This glaſs may be deprived of the bubbles it uſually contains, by keeping it for a time in a violent heat; it is then tranſparent, and may be cut like a diamond. According to Crell, its ſpecific gravity is to that of water as three to one, while that of diamond is as three and a half to one. This glaſs is inſoluble in water, &c. A ſkeleton of nineteen pounds, burned, affords five pounds of phoſphorc glaſs.

I pulverize this glaſs, mix it with equal parts of powder of charcoal, put it into a porcelain retort well coated, the beak of which I partly plunge into the water of the receiver, ſo that nothing can eſcape but air or phoſphoric gas. I adapt a large tube to the tubulure of the receiver, and plunge it into a veſſel filled with water. The fire being raiſed by degrees, the phoſphorus comes over the moment the mixture is ignited. The phoſphorus ſublimes, partly in the form of a fume which congeals; and is precipitated upon the ſurface of the water, partly in the form of inflammable gas, and partly reſembling melted wax, which drops in beautiful tranſparent tears from the neck of the retort. The theory of this operation is eaſily explained. The phoſphoric acid is diſplaced by the ſulphuric acid, as is ſhewn by the large quantity of ſulphate of lime which is obtained. All the other operations tend only to concentrate this phoſphoric acid, which is ſtill combined with other animal ſubſtances, and the diſtillation with charcoal decompoſes the phoſphoric acid; its oxigene unites with the coal, and affords carbonic acid, while the phoſphorus itſelf becomes diſengaged.

To purify the phoſphorus, a piece of chamois leather is moiſtened, and the maſs of phoſphorus is put into it. This being immerſed in a veſſel of boiling water, the phoſphorus melts, and is paſſed through the ſkin like mercury. The ſkin cannot be uſed more than once; the phoſphorus, which might be paſſed a ſecond time, would become coloured. This proceſs was contrived by Mr. Pelletier.

In order to form phoſphorus into ſticks, a funnel with a long neck may be uſed, the lower orifice being cloſed with a ſmall cork, or piece of ſoft wood. The funnel is then to be filled with water, and phoſphorus put into it; and this being plunged in boiling water, the heat is communicated to that of the funnel; and melts the phoſphorus, which runs into the neck, and takes that form. The funnel is then removed into a veſſel of cold water; and when the phoſphorus is perfectly cooled, the cork is taken out, and the phoſphorus thruſt out of its mould with a ſmall piece of wood.

Phoſphorus is kept under water. After a certain time it loſes its tranſparency, becomes covered with a white powder, and the water is acidulated *.

In whatever manner phoſphorus may be made, it is always one and the ſame ſubſtance, characterized by the following properties:— It is of a fleſh colour, and evidently tranſparent. It has the conſiſtence of wax; and may be cut in pieces with a knife, or twiſted aſunder with the fingers; in which laſt caſe the precaution muſt be taken of frequently plunging it into water, to prevent its taking fire.

When phoſphorus is placed in contact with

---

* This ſlow acidification of the phoſphorus ſeems to be reverſed by the ſun's light. Sticks of phoſphorus, which had become covered with a white powder, were expoſed under water to the ſun's light, which converted them to an orange yellow colour in ſuch parts as were acted upon by the direct light. This fact appears to be of the ſame nature as the colouring of the nitrous acid, and other ſimilar phenomena. T.

the air, it emits a white fume. It is luminous in the dark; and a ſolid ſtick of phoſphorus may be uſed to write with, like a crayon. The marks are viſible in the dark; and this means has often been uſed to create fear and aſtoniſhment in the minds of the ignorant.

When phoſphorus is expoſed to twenty-four* degrees of heat, it takes fire with decrepitation, burns with a very bright flame, and emits a very abundant white fume, which is luminous in the dark. The reſidue of the combuſtion is a red cauſtic ſubſtance, which attracts the humidity of the air, and becomes reſolved into a liquor. This is the phoſphoric acid, which we ſhall proceed to treat of.

Mr. Wilſon affirms that the ſolar rays ſet fire to phoſphorus; and proves that this flame has the colour proper to the phoſphorus, and not that of the ray itſelf.—Letter of Mr. Wilſon to Mr. Euler, read at the Royal Society of London in June 1779.

---

* Twenty-four degrees of Reaumur anſwer to eighty-ſix of Fahrenheit. The vivid combuſtion of phoſphorus takes place at different temperatures, according to its purity; but the preſent is very low. By taking phoſphorus into a freezing atmoſphere, its faint flame diſappears, and it ſeems to require a temperature of ſixty degrees to revive it. I found the vivid combuſtion to take place at one hundred and ſixty degrees. T.

An advantageous uſe has lately been made of the combuſtible property of phoſphorus, to procure fire conveniently, and in all ſituations, by means of phoſphoric tapers or matches, and the philoſophical bottles, the method of making which we ſhall point out.

1. The moſt ſimple proceſs for making the phoſphoric matches, conſiſts in taking a glaſs tube, four inches long and one line in diameter, cloſed at one end. A ſmall quantity of phoſphorus is introduced into the tube, and puſhed to its further end; after which a taper covered with a ſmall quantity of wax is introduced into the ſame tube. The open end is then hermetically ſealed, and the other end is plunged into boiling water. The phoſphorus melts, and fixes itſelf upon the match.

A line is drawn at one-third of the length of the tube, with a flint, that it may be broken as occaſion may require.

The match is to be drawn out quickly, to inflame the phoſphorus.

The proceſs of Mr. Lewis Peyla, to make the inflammable bougies, conſiſts in taking a glaſs tube, five inches long, and two lines wide, one end of which is ſealed with the blow-pipe. Small tapers of wax are prepared with three double threads of cotton twiſted together. The extremity of the match or taper is half an inch long, and muſt not be covered with wax.

A piece of lead is laid in a ſaucer filled with water; and upon this the phoſphorus is cut, beneath the water, into fragments of the ſize of a grain of millet. One of theſe grains is to be dried, and introduced into the tube of glaſs; after which the fortieth part of a grain of very dry ſulphur is to be added, that is to ſay, half the weight of the phoſphorus. One of the bougies is then taken, and its extremity dipped in very clear oil of wax. If too large a quantity riſes, it muſt be dried with a cloth.

The match is introduced into the tube with a turning or twiſting motion between the fingers.

The bottom of the tube muſt then be plunged into boiling water, to ſoften the phoſphorus; obſerving to keep it no longer than three or four ſeconds in the water.

The other extremity of the tube is afterwards ſealed.

Theſe bougies muſt be kept in a tin tube, to avoid the danger of inflammation.

2. To form the phoſphoric bottles, a glaſs bottle is heated, by fixing it in a ladle full of ſand, and two or three ſmall pieces of phoſphorus are then introduced into it. A ſmall red-hot iron wire is uſed to ſtir the phoſphorus

about, and cauſe it to adhere to the internal ſurface of the bottle, where it forms a reddiſh coating. The heated wire is introduced repeatedly; and when all the phoſphorus is thus diſtributed within the bottle, it is left open for a quarter of an hour, and afterwards corked. When this is uſed, a common match tipped with ſulphur is introduced into the bottle, turned round, and quickly drawn out. The phoſphorus which ſticks to the ſulphur takes fire, and lights the match.

The theory of this phenomenon depends on the circumſtance that the phoſphorus is ſtrongly dried, or half calcined, and needs only the contact of air to ſet it on fire.

Phoſphorus is ſoluble in oils, more eſpecially the volatile oils, which then become luminous. If this ſolution be kept in a bottle, a phoſphoric flaſh, which emits a ſmall quantity of light, will be ſeen every time the bottle is opened. The oil of cloves is uſed in this operation. The combination of phoſphorus and oil appears to exiſt naturally in the glow-worm, lampyris ſplendidula Linnæi. Forſter of Gottingen obſerves, that the ſhining matter of the glow-worm is liquid. If the glow-worm be cruſhed between the fingers, the phoſphoreſcence remains on the finger. Henckel reports, in the eighth diſſertation of his Pyritologia, that one of his friends, of a ſanguine temperament, after having danced much, perſpired to ſuch a degree that he thought his life in danger. While he undreſſed, traces of phoſphoric flame were ſeen on his ſhirt, which left yellow red ſpots behind them, reſembling the reſidue of burned phoſphorus: this light was long viſible.

A phoſphoric gas may be extracted from phoſphorus, which takes fire by the mere contact of the air. Mr. Gengembre has ſhewn the method of extracting it, by digeſting alkalis upon it (Memoir read to the Academy at Paris the 3d of May, 1783), and at the ſame time I ſhewed that it might be extracted by means of acids, which are decompoſed upon phoſphorus. I have likewiſe taken notice, in my Memoir upon the decompoſition of the nitric acid by phoſphorus, that when the acid is digeſted upon it, a gas eſcapes, which takes fire in the receiver, and has ſeveral times afforded me the appearance of flaſhes of lightning ſtriking through the cavity of the veſſels. But this phenomenon diſappeared as ſoon as the vital air was abſorbed.

It is to the diſengagement of a gas of this nature that we may attribute the ignes fatui which play about burying-grounds, and generally in all places where animals are buried and putrefy. It is to a ſimilar gas that we may refer the inflammable air which conſtantly burns in certain places, and upon the ſurface of certain cold ſprings.

Phoſphorus is found in the three kingdoms. Mr. Gahn found the phoſphoric acid in lead. Siderite is a phoſphorus of iron. The ſeeds of rocket, of muſtard, of garden creſſes, and of wheat, treated by Margraaf, afforded him a fine phoſphorus. Mr. Meyer of Stetin has announced, in the Chemical Annals of Crell for the year 1784, that the green reſinous part of the leaves of plants contains the phoſphoric acid. Mr. Pilatre du Rozier renewed the opinion of Rouelle in 1780 (Journal de Phyſique for November), who conſidered the phoſphoric acid as analogous to that of mucilaginous bodies; and he affirms that the diſtillation of pyrophorus affords five or ſix grains of phoſphorus in the ounce. The phoſphoric acid exiſts in urine, bones, horns, &c. Mr. Maret, by treating twelve ounces of beef by combuſtion, obtained three gros of tranſparent phoſphoric glaſs. Mr. Crell obtained it from beef ſuet and human fat; Mr. Hankwitz from excrements; Leidenfroſt from old cheeſe; Fontana from fiſhes bones; Berniard from egg-ſhells, &c. Meſſrs. Macquer and Mr. Struve found the phoſphoric acid in the gaſtric juice.

The moſt intereſting combination of phoſphorus is that which it forms with vital air. This is always the phoſphoric acid ; but the acid appears to be modified by the manner in which it is made.

Phoſphorus unites with oxigene—1. By deflagration, or the rapid combuſtion. 2. By the ſlow combuſtion. 3. In the humid way, more eſpecially by the decompoſition of the nitric acid.

1. If phoſphorus be expoſed to a dry heat of twenty-four degrees, it takes fire, emits a white denſe fume, and leaves a reddiſh reſidue, which powerfully attracts the humidity of the air, and becomes reſolved into a liquor. This combuſtion may be performed under glaſs veſſels; in which caſe white flocks are depoſited on the ſides of the glaſs, which reſolve into a liquor by the contact of moiſt air, and form the phoſphoric acid. Care is taken to introduce an additional quantity of vital air when the combuſtion of the phoſphorus has not been completed.

Mr. Lavoiſier has burned phoſphorus, by the aſſiſtance of a burning glaſs, under a glaſs veſſel plunged in mercury (Memoirs of the Royal Academy of Sciences, 1777.)

Margraaf had obſerved that air is abſorbed in this operation. M. Morveau, in the year 1772, had declared the ſame from his own experiments; and Fontana proved that phoſphorus abſorbs and vitiates air, like every other combuſtible ſubſtance. Meſſ. Lavoiſier and De la Place found that forty-five grains of phoſphorus abſorbed 65,62 of vital air.

The acid obtained by this means is impure. It always contains phoſphorus in ſolution, not ſaturated with oxigene.

2. Phoſphorus is moſt completely decompoſed by the ſlow combuſtion. For this purpoſe the neck of a glaſs funnel is inſerted into a bottle, and ſticks of phoſphorus are diſpoſed round in the funnel, ſo as not to touch each other; a ſmall piece of glaſs tube being put into the neck, to prevent their falling through. A paper is tied over the funnel. The phoſphorus is ſlowly decompoſed; and, as it becomes converted into a fluid, it flows into the bottle, where it forms a liquid without ſmell or colour. This acid almoſt always retains a ſmall quantity of undecompoſed phoſphorus, from which it may be cleared by digeſting alcohol upon it, which diſſolves the phoſphorus without volatilizing the acid.

One ounce of phoſphorus produces in this manner three ounces of phoſphoric acid.

3. The nitric acid may be decompoſed by

digeſtion upon phoſphorus. This nitrous gas is diſſipated; and the oxigene remains united to the phoſphorus, with which it forms phoſphoric acid. When the nitric acid is very concentrated, the phoſphorus takes fire, and burns at its ſurface. I publiſhed this proceſs, with all the circumſtances of the operation, in 1780, the ſame year in which the excellent Memoir of Mr. Lavoiſier on the ſame queſtion was printed, and of which I had then no knowledge.

The water in which phoſphorus is kept, contracts acidity in the courſe of time; which ſhews that the water itſelf is decompoſed, and yields its oxigene to the phoſphorus.

Phoſphorus precipitates ſome metallic oxides from their ſolutions in the metallic ſtate. It is obſerved that acid is formed in this operation; which proves that the oxigene quits the metal to unite with the phoſphorus.

The phoſphoric acid is clear, inodorous, without being corroſive. It may be concentrated to dryneſs. Crell having concentrated it to dryneſs, found its ſpecific gravity, compared with water, to be as 3.1.

This acid is very fixed. If it be concentrated in a mattraſs, the water is firſt diſſipated, a ſmell of garlic is ſoon perceived, which ariſes from a portion of phoſphorus, from which this acid is difficultly cleared; and vapours likewiſe riſe. The liquor becomes turbid, aſſumes a milky appearance, and a paſty conſiſtence; and if the matter be put into a crucible, on hot coals, it boils conſiderably. The vapour which iſſues renders the flame green; and the maſs at laſt becomes converted into a white tranſparent glaſs, inſoluble in water.

The phoſphoric acid has no action on quartz.

It diſſolves clay with ebullition.

It diſſolves barytes; and unites to clay with ſingular facility, with which it forms a ſalt of ſparing ſolubility. The ſolution, when well charged, lets fall, at the end of four-and-twenty hours, cryſtals in ſmall, thin, flattened needles, ſeveral lines long, and obliquely truncated at each end. The phoſphoric acid precipitates lime from lime-water, and forms a true phoſphate of lime, very ſimilar to the baſis of bones, and decompoſable by the mineral acids like that ſubſtance.

The phoſphoric acid, ſaturated with potaſh, forms a very ſoluble ſalt, which affords tetrahedral cryſtals terminating in tetrahedral pyramids. This phoſphate is acid, ſwells up on hot coals, and is difficult of fuſion. Lime-water decompoſes it.

Soda, combined with the phoſphoric acid, affords a ſalt of a taſte reſembling that of the muriate of ſoda. This phoſphate does not cryſtallize, but becomes converted into a gummy and deliqueſcent maſs by evaporation. M. Sage affirms that the phoſphate of ſoda prepared with the acid of the ſlow combuſtion, forms a ſalt ſuſceptible of cryſtallization.

Dr. George Pearſon has combined the phoſphoric acid obtained by nitric acid with ſoda, and obtained a neutral ſalt in rhomboids.

This ſalt, though ſaturated, turns ſyrup of violets green, effloreſces in the air, and has a ſaline taſte reſembling that of common ſalt. It purges in the doſe from ſix to eight drams, without producing either nauſea or griping, and has not a diſagreeable taſte.

The phoſphoric acid acts only on a ſmall number of metallic ſubſtances. On this ſubject the works of Meſſ. Margraaf and De Morveau may be conſulted.

The phoſphoric acid has a very evident action on oils. Mixed with an equal portion of olive oil, it acquires a fawn colour by mere agitation, which ſubſiſts even after the ſeparation. This ſhade increaſes if the two fluids be digeſted together; the acid becomes thick; and the oil which floats above becomes black and coaly, and emits a ſtrong ſmell.

CHAP. X.

Concerning certain Subſtances obtained from Animals for the Uſe of Medicine and the Arts.

THERE is not perhaps any animal product whoſe virtues have not been celebrated by ſome of the phyſicians; and there are few animals which have not at ſome time or other been mentioned as contributing to the advantage of medicine. Time however has happily condemned to oblivion thoſe productions which ought never to have poſſeſſed celebrity: and we ſhall accordingly, on the preſent occaſion, attend only to ſuch as experience has ſhewn to poſſeſs the virtues and powers attributed to them.

We ſhall not therefore treat of the lungs of the fox, the liver of the wolf, the feet of the elk, the jaws of the carp, the neſts of the ſwallow, the powder of the toad, the dung of the peacock, the heart of the viper, the fat of the badger, nor even that of the hanged malefactor.

Various quadrupeds, cetaceous animals, birds, and fiſhes, afford products in which chemical and medical experience has aſcertained very evident virtues.

ARTICLE I.

Concerning the Products afforded by Quadrupeds.

Under this article we ſhall treat of the products moſt in uſe which are extracted from quadrupeds. Theſe are caſtoreum, muſk, and hartſhorn.

1. The name of Caſtoreum is given to an unctuous fluid contained in two pouches ſituated in the inguinal region of the male or female caſtor. An accurate deſcription of it may be ſeen in the Encyclopédie. This very odorant ſubſtance is ſoft, and nearly fluid when recently extracted from the animal; but it dries in the courſe of time. It has an acrid, bitter, and nauſeous taſte; and its ſmell is ſtrong, aromatic, and even ſtinking.

Alcohol diſſolves a reſin which colours it; water extracts an abundant principle. By evaporation of the water a ſalt is obtained, the nature of which is little known. Caſtoreum affords by diſtillation a ſmall quantity of volatile oil, ammoniac, &c.

The uſes of caſtor in the œconomy of the animal are unknown. The ancients had the credulity to believe that the creature itſelf took it when its ſtomach was weak.

It is uſed in medicine as a powerful antiſpaſmodic, in the doſe of a few grains in ſubſtance; and it enters as a component part into boluſes, extracts, &c. It is advantageouſly joined with opium; and its ſpirituous tincture is alſo preſcribed in ſuitable liquids, in a doſe from twenty-four to thirty-ſix drops.

We ſee clearly, from the little chemical information we poſſeſs reſpecting this ſubſtance, that it is a reſin joined with a mucilage, and a ſalt which facilitates the union of its principles.

2. The name of Muſk is given to a perfume obtained from various animals. In 1726 an animal was received, under the name of the Muſk Animal, in the Royal Menagerie, which came from Africa, and reſembled the civet. M. Perrault has left a deſcription of it. It was ſupported ſix years upon raw fleſh. M. De la Peyronnie gave a very good deſcription of it to the Academy of Sciences for the year 1731.

The organ which contained the muſk was ſituated near the genital parts (it was a female). At the aperture of the bag which contained the muſk the ſmell was ſo ſtrong, that M. De la Peyronnie could not inſpect it without inconvenience.

convenience. This liquor is prepared by two glands, which tranſmit it into the common reſervoir through a number of ſmall perforations.

The other animal which affords muſk in the Eaſt, is of the claſs of ſquirrels. It is very common in Chineſe Tartary. It carries the muſk in a bag beneath the navel. This bag, projecting outwards of the ſize of a pullet's egg, is formed of a membranous and muſcular ſubſtance, provided with a ſphincter. Many glands are obſervable within, which ſeparate the humour. As ſoon as the beaſt is killed, this bladder is cut off and tied up: but its contents are adulterated with the teſticles, the blood, and other offal of the animal: for each creature affords no more than three or four gros. Muſk muſt be choſen ſoft, unctuous, and odorant; and ought to be conſumed totally upon hot coals. The muſk of Tonquin, which is moſt eſteemed, is contained in bags covered with brown hair: but that of Bengal is covered with white hair.

Muſk contains nearly the ſame principles as caſtoreum. The ſmell of pure and unmixed muſk is too ſtrong and oppreſſive. It is rendered mild by mixture with other ſubſtances. It is little uſed in medicine; is a powerful antiſpaſmodic in ſome caſes; but ought to be adminiſtered with caution, becauſe it often excites nervous affections inſtead of calming them.

The ſmell of muſk predominates in certain animals. M. de la Peyronnie knew a man from whoſe left arm-pit there was emitted ſo ſtrong a ſmell of muſk during the ſummer, that he was obliged to weaken it to avoid inconvenience.

3. Hartſhorn affords ſeveral products which are much employed in medicine. The preference is given to this horn becauſe it contains leſs earthy ſalt than bones; but all kinds of horn may be uſed indiſcriminately.

Hartſhorn was formerly calcined with the greateſt care, and uſed as a remedy againſt alvine fluxes.

The products of hartſhorn which are moſtly uſed at preſent, are thoſe obtained by diſtillation. An alkaline phlegm is firſt obtained, which is called the Volatile Spirit of Hartſhorn. Next comes over a reddiſh oil, more or leſs empyreumatic; and a very great quantity of carbonate of ammoniac, ſoiled and coloured by the empyreumatic oil. The oil which colours the ſalt may be diſengaged by means of ſpirit of wine, which diſſolves it. The coaly reſidue contains natrum, ſulphate, and phoſphate of lime; from which phoſphorus may be obtained by the proceſſes already deſcribed.

The ſpirit and the ſalt obtained from hartſhorn are uſed in medicine as good antiſpaſmodics.

The oil duly rectified forms the animal oil of Dippel. As the higheſt virtues have been attributed to this ſubſtance, a thouſand methods have been attempted to purify it. For a long time it was uſual to rectify it a great number of times, in order to have it white and fluid. But Meſſ. Model and Baumé have adviſed taking only the firſt portion which comes over, becauſe this is the moſt attenuated, and the whiteſt. Rouelle adviſes diſtillation with water; and as the moſt volatile part only riſes with the heat of boiling water, there is a certainty of having it very fine by this means. For my part, I diſtil the empyreumatic oil with the earth of Murviel, which retains all the colouring part; and by this means I have it at once white and attenuated.

This is odorant, and has all the properties of the volatile oils: but it turns ſyrup of violets green, as Mr. Parmentier has obſerved; which proves that it retains a ſmall quantity of volatile alkali. This oil is uſed in doſes of a few drops in nervous affections, epilepſy, &c. It is uſed externally, by rubbing it on the ſkin, as a ſedative, and to remove obſtructions; but the great virtues formerly attributed to it are not much credited at preſent.

ARTICLE II.

Concerning certain Products afforded by Fiſhes.

The oil of fiſh, and ſpermaceti, are the moſt uſed among the products obtained from fiſhes.

Spermaceti is a concrete oil extracted from the cacholot. The name of Sperma-ceti is very improper. Theſe animals are of a prodigious ſize, and afford large quantities of this matter. Plomet relates that in 1688 a Spaniſh ſhip took a whale whoſe head afforded twenty-four barrels of brains, and the body ninety-ſix barrels of fat. This ſpermaceti is always mixed with a certain quantity of inconcreſcible oil, which is carefully removed.

Spermaceti burns with a very white flame. It is made into candles at Bayonne and at St. Jean de Luz. Theſe candles are of a ſhining white colour, become yellow in proceſs of time, but not ſo ſoon as wax and the denſe oils.

If it be diſtilled on a naked fire, it does not afford an acid phlegm, but riſes totally, at the ſame time that it aſſumes a reddiſh tinge. Several repeated diſtillations deprive it of its natural conſiſtence.

The ſulphuric acid diſſolves it; and this ſolution is precipitated like the oil of camphor.

The nitric and muriatic acids have no action upon it.

Cauſtic alkali diſſolves ſpermaceti, and forms a ſoap which gradually acquires ſolidity.

Alcohol diſſolves ſpermaceti by the aſſiſtance of heat, but lets it fall as it cools. Ether likewiſe diſſolves it.

The fixed and volatile oils diſſolve it by the aſſiſtance of heat.

This ſubſtance was formerly much uſed. It was given as an emollient and ſoftening remedy: but at preſent it is almoſt forſaken, and not without cauſe; for it is heavy, inſipid, and nauſeous.

The egg, the ſcales, and the black fluid of the cuttle-fiſh are ſtill uſed in medicine. The eggs deterge the kidneys, and excite urine and the courſes. The ſcales and bones of the cuttle-fiſh are applied to nearly the ſame uſes: they are likewiſe uſed as an aſtringent; and enter into dentifrice powders, collyria, &c. The goldſmiths likewiſe uſe them to make their moulds for caſting ſpoons, forks, toys, &c. becauſe its ſpongy part eaſily receives the impreſſion of metals. The black humour of the cuttle-fiſh, which is found in a bag near the cœcum, and of which Mr. Le Cat has given a deſcription, may be uſed inſtead of ink. We read in the Satires of Perſius that the Romans uſed it as an ink;

and Cicero calls it Atramentum. It ſeems that the Chineſe uſe it as the baſis of their famous ink. "Sepia piſcis eſt qui habet ſuccum nigerrimum, inſtar atramenti, quem Chinenſes cum brodio orizæ, vel alterius leguminis, inſpiſſant et formant, et in univerſum orbem tranſmittunt, ſub nomine Atramenti Chinenſis" (Pauli Hermani Cynoſura, t. i. p. 17, par. 2.) Pliny was of opinion that the black humour of the cuttle-fiſh was its blood. Rondelet has proved that it is the bile. This is the fluid the cuttle-fiſh diſgorges when in danger: a very ſmall quantity is ſufficient to blacken a large quantity of water.

Calcined oyſter ſhells are likewiſe uſed in medicine as an abſorbent.

The oil extracted from fiſh is of the greateſt uſe in the arts.

ARTICLE III.

Concerning certain Products afforded by Birds.

Moſt of the birds are uſed at our tables as a delicate food, but few afford any medical products. The eagle ſtones, to which ſo much virtue had been attributed for facilitating labours, the plaſters of ſwallows neſts, and other ſimilar ſubſtances, have all fallen into neglect, as the natural conſequence of the obſervation of matter of fact being ſubſtituted in the place of credulity and ſuperſtition. The analyſis of eggs begins to be known. They conſiſt of four parts: an oſſeous covering, called the ſhell; a membrane which covers the conſtituent parts of the egg; the white; and the yolk, which occupies the centre.

The ſhell, like bones, contains a gelatinous principle, and the phoſphate of lime.

The white is of the ſame nature as the ſerum of blood. It renders ſyrup of violets green, and contains uncombined chalk; heat coagulates it; by diſtillation it affords a phlegm which eaſily putrefies; it becomes dry like horn; and carbonate of ammoniac, and empyreumatic oil come over. A coal remains in the retort, which affords ſoda, and phoſphate of lime. M. Deyeux has alſo obtained ſulphur by ſublimation.

Acids and alcohol coagulate it.

If it be expoſed to the air in thin leaves, it dries, and becomes conſiſtent; and it is on this property that the cuſtom is founded of paſſing the white of egg over the ſurface of paintings, to give them that brightneſs which is produced by varniſh, and alſo to defend them from the air. The drying may be haſtened by quick-lime; and this mixture affords a lute of the greateſt tenacity.

The yolk of egg likewiſe contains a lymphatic ſubſtance, mixed with a certain quantity of mild oil, which on account of this mixture is ſoluble in water. It is this animal emulſion which is known in France by the name of *lait de poulle*. Yolk of egg expoſed to the fire aſſumes a conſiſtence leſs hard than the white. If it be bruiſed, it appears to have ſcarcely any conſiſtence; and if it be ſubjected to the preſs, it gives out the oil it contains. This oil is very emollient, and is uſed externally as a liniment. There is the greateſt analogy between the eggs of animals and the ſeeds of vegetables; ſince both contain an oil rendered ſoluble in water by the admixture of a glutinous ſubſtance.

The yolk of egg renders oils and reſins ſoluble; and this ſubſtance is accordingly much uſed for that purpoſe.

Calcined egg-ſhells are an abſorbent.

White of egg is ſucceſsfully uſed to clarify vegetable juices, whey, liquors, &c. It coagulates by heat; and then riſes to the ſurface of theſe fluids, carrying with it all the impurities they contain.

ARTICLE IV.

Concerning certain Products afforded by Inſects.

Millepedes, cantharides, kermes, cochenille, and lac, are the only ſubſtances we ſhall here treat of, becauſe theſe are not only the moſt uſed, but are likewiſe the beſt known among the products of inſects.

1. Cantharides.—The cantharides are ſmall inſects with greeniſh wings. They are very common in hot countries; and are found on the leaves of the aſh, the roſe-tree, the poplar, the walnut-tree, the privet, &c.

Cantharides in powder, applied to the epidermis, cauſe bliſters, excite heat in the urine, ſtrangury, thirſt, and fever. They produce the ſame effect taken internally in a ſmall doſe. We read in Paré that a courtezan having preſented a ragout powdered with cantharides to a young man who ſupped with her, this unfortunate perſon was attacked with a priapiſm, and loſs of blood by the anus, of which he died. Boyle affirms that pains at the neck of the bladder have been produced by the handling of cantharides.

We are indebted to Mr. Thouvenel for ſome information reſpecting the conſtituent principles of theſe inſects. Water extracts a very abundant principle, which colours it of a reddiſh yellow, and alſo a yellowiſh oily principle. Ether takes up a green very acrid oil, in which the virtue of the cantharides moſt eminently reſides. So that an ounce of cantharides affords—

	gros.	grains.
Reddiſh yellow bitter extract — —	3	0
Yellow oily matter — — —	0	12
Green oily ſubſtance, analogous to wax —	0	60
Parenchyma, inſoluble in water and alcohol —	4	0
	8	0

To form a tincture which unites all the properties of cantharides, a mixture muſt be made of equal parts of water and of alcohol, and the inſects digeſted in it. If this tincture be diſtilled, the ſpirit which comes over retains the ſmell of cantharides.

If ſpirit of wine alone be uſed, it takes up merely the cauſtic part: hence it appears that the virtue of theſe inſects may be increaſed or diminiſhed according to the exigence of the caſe.

The tincture of cantharides may be uſed with ſucceſs externally, in the doſe of two gros, four gros, one or even two ounces, in rheumatic pains, ſciatica, wandering gout, &c. It heats the parts; accelerates the circulation; excites evacuations by perſpiration, urine, or ſtool, according to the parts to which it is applied.

Mr. Thouvenel tried upon himſelf the effect of the green waxy matter. When applied on the ſkin in the doſe of nine grains, it raiſed a bliſter full of ſeroſity.

2. The wood-lice, millepedes, aſelli, porcelli.—This inſect is uſually found in moiſt places, under ſtones, or beneath the bark of old trees. It avoids the light, and endeavours to conceal itſelf when diſcovered. When it is touched, it rolls up in the form of a globe. This inſect is uſed in medicine as an inciſive, aperitie, and alterative remedy. It is preſcribed either pounded alive, and put into a proper liquid; or dried and pulverized, in which laſt form they enter into extracts, pills, &c. The millepedes are given in the doſe of fourteen, fifteen, twenty, or more, according to the exigency. Mr. Thouvenel has given us ſome information concerning the conſtituent principles of theſe inſects. He obtained by diſtillation an inſipid or alkaline phlegm; the reſidue afforded an extractive matter, an oily or waxy ſubſtance ſoluble in ſpirit of wine only, and marine ſalt with an earthy and an alkaline baſe.

3. Cochenille.—Cochenille is a ſubſtance uſed in dyeing ſcarlet and purple. It is met with in commerce in the form of ſmall grains of a ſingular figure, moſtly convex with little grooves on one ſide, and concave on the other. The colour of good cochenille is grey mixed with reddiſh and white. It is at preſent well determined that it is an inſect. Simple inſpection with a magnifier ſufficiently proves this; and the wings and feet of this inſect may be developed by expoſing it to the vapour of boiling water, or by digeſting it with vinegar. The cochenille is collected in Mexico, upon plants to which the names of Indian Fig, Raquette Nopal, are given. Theſe plants bear fruits which reſemble our figs; tinge the urine of thoſe who eat them; and probably communicate to the cochenille the property which makes it uſeful to the dyer. The Indians of Mexico cultivate the nopal near their habitations, and ſow as it were the inſect which affords the cochenille. They make ſmall neſts of moſs or fine herbs, put twelve or fourteen cochenilles into each neſt, place three or four of theſe neſts on each leaf of the nopal, and faſten them there by the prickles of the plant: in the courſe of a few days, thouſands of ſmall inſects iſſue out, and fix themſelves upon the parts of the leaf

which are beſt ſheltered, and afford the moſt nouriſhment. The cochenilles are collected ſeveral times in the courſe of the year: and are deprived of life by ſcalding them, or by putting them into an oven: after which they are dried in the ſun. Two kinds of cochenille are diſtinguiſhed: the one which is produced without culture, and is called Sylveſtre; and the other cultivated, which is called Meſteque. This laſt is preferred. It has been calculated, in the year 1736, that eight hundred and eighty thouſand pounds weight of cochenille was annually imported into Europe. Mr. Ellis has communicated a very good deſcription of the cochenille to the Royal Society of London.

This ſubſtance is more eſpecially uſed in dyeing: its colour takes readily upon wool; and the moſt ſuitable mordant is the muriate of tin. Mr. Macquer has diſcovered a method of fixing this colour upon ſilk, by impregnating the ſilk with a ſolution of tin before it is plunged into the bath of cochenille; inſtead of mixing a ſolution in the baths, as is done for woollens.

4. Kermes.—Kermes is a kind of excreſcence, of the ſize of a juniper-berry, which is greatly employed in medicine and the arts.

The tree which bears it is known by the

name of Quercus Ilex. It grows in hot countries; in Spain, Languedoc, Provence, &c. The female of the coccus fixes itſelf on the plant: it has no wings, but the male has. When ſhe is fecundated, ſhe becomes large by the development of her eggs: ſhe periſhes, and the eggs are hatched. It is collected before the development of the eggs; for which purpoſe, the morning is taken, before the heat has acted upon the eggs. The grains are collected and dried, to develop the red colour; they are then ſifted, to ſeparate the powder; and laſtly they are ſprinkled with good vinegar, to kill the inſect, which would otherwiſe come forth in a ſhort time.

Kermes is much uſed in the arts: it affords a good red, but leſs brilliant than that of the cochenille.

A very celebrated ſyrup of kermes is made, by mixing three parts of ſugar with one of the grains of kermes pulverized. This mixture is kept for a day in a cool place: the ſugar during this time unites with the juice of the kermes; and forms with it a liquor which, when drawn off by expreſſion, has the conſiſtence of ſyrup. The celebrated confectio alkermes is made with this ſyrup.

The grains of kermes given in ſubſtance, from half a ſcruple to a gros or dram, are celebrated for preventing abortion.

The grain and the ſyrup of kermes are an excellent ſtomachic.

5. Lac, or gum-lac.—This is a kind of wax, collected by red winged ants from flowers in the Eaſt Indies, which they tranſport to the ſmall branches of the tree where they make their neſts. The neſts are full of ſmall cells, in which a red grain is found when the maſs is broken. This ſmall grain is, to all appearance, the egg from which the flying ant derives its origin.

Mr. Geoffroy has proved, in a Memoir inſerted among thoſe of the Academy for the year 1714, that this muſt have been a kind of comb, approaching to the honeycomb of bees, the cells of which are formed of a ſubſtance analogous to wax *.

The colouring part of lac may be taken up by water, which, when evaporated, leaves the colouring principle diſengaged. It is the fine

---

* For a deſcription and drawing of the inſect which affords the lac, conſult Keir in the Philoſ. Tranſ. vol. lxxi. p. 374; alſo Saunders, in the ſame work, vol. lxxix. for the method of purifying the lac; or a ſhort abridgment of both, in Nicholſon's Firſt Principles of Chemiſtry, p. 490. T.

lake uſed for dyeing. Lake is imitated by extracting the colouring principle of certain plants by well-known proceſſes.

CHAP. XI.

Concerning ſome other Acids extracted from the Animal Kingdom.

INDEPENDENT of the acids afforded by the various parts of the human body, which have been ſeparately examined by us, we find acids in moſt inſects. Liſter points out one which may be extracted from millepedes (Collect. Acad. tom. ii. p. 303). Mr. Bonnet has obſerved that the fluid ejected by the great forked-tail caterpillar of the willow was a true acid, and even every active (Savans Etrangers, tom. ii. p. 276): Bergmann compares it to the moſt concentrated vinegar. The abbé Boiſſier de Sauvages has remarked, that in that illneſs of the ſilk-worm, which is called muſcardin, the humour of the worm is acid. Mr. Chauſſier of Dijon obtained an acid from graſshoppers, from the May-bug, from the lampyris, and ſeveral other inſects, by digeſting them in alcohol. The ſame chemiſt has made an intereſting courſe of experiments on the acid of the ſilk-worm. He gives two methods of extracting it. The firſt conſiſts in bruiſing the chryſalides, and ſtraining them through a cloth. The fluid which paſſes is ſtrongly acid; but the acid is weakened by various foreign ſubſtances, of which it may be cleared by digeſtion in ſpirit of wine. The fluid which paſſes the filter after this digeſtion, is of a fine orange colour. More ſpirit of wine is to be poured upon it. At every addition of ſpirit a light whitiſh precipitate is formed; and the additions of ſpirit are to be continued until no more precipitate appears.

Inſtead of bruiſing the chryſalides they may be infuſed in ſpirit of wine, which diſſolves all the acid; and as this acid is leſs volatile than the ſpirit, this laſt may be evaporated, and the reſidue filtered. By theſe precautions the acid may be cleared of its ſpirit of wine, and of the mucous matter which was diſſolved, but remains on the filter.

Mr. Chauſſier has proved that this acid exiſts in all the ſtates of the ſilk-worm, even in the eggs; but that in the egg and in the worm it does not exiſt in a diſengaged ſtate, but combined with a gummy glutinous ſubſtance.

The acid of inſects which is beſt known, and upon which moſt has been written, is the acid of ants, or the formic acid. This acid is ſo far in a diſengaged ſtate, that the tranſpiration of theſe animals, and their ſimple contact without any alteration, proves its exiſtence.

The authors of the fifteenth century had obſerved, that the flower of chickory thrown into an ant-hill became as red as blood.—See Langham, Hieronimus Tragus, John Bauhin.

Samuel Fiſher is the firſt who diſcovered the acid of ants, in a courſe of experiments for the analyſis of animal ſubſtances by diſtillation. He even tried its action on lead and iron; and communicated his obſervations to J. Vray, who inſerted them in the Philoſophical Tranſactions in the year 1670. But it was the celebrated Margraaf who more particularly examined the properties of this acid in 1749. He combined it with many ſubſtances, and concluded that it greatly reſembled the acetous acid. In 1777 this ſubject was again reſumed by Meſſrs. Ardvidſſon and Oerhn; and treated in a manner which leaves little to be deſired, in their diſſertation publiſhed at Leipſic.

The ant which affords the greateſt quantity of acid, is the large red ant which is found in dry and elevated places.

The months of June and July are moſt favourable for the extraction of this acid; they are then ſo penetrated with it, that their ſimple paſſing over blue paper is ſufficient to turn it red.

Two methods may be uſed to obtain this acid; diſtillation, and lixiviation.

To extract the acid by diſtillation, the ants are firſt dried by a gentle heat, and put into a retort, to which a receiver is adapted, and the fire is raiſed by degrees. When all the acid is come over, it is found in the receiver mixed with a ſmall quantity of empyreumatic oil, which floats upon it, and may be ſeparated by a funnel. Meſſrs. Ardvidſſon and Oerhn obtained, in this manner, from each pound of ants ſeven ounces and a half of acid whoſe ſpecific gravity, at the temperature of fifteen degrees, was to that of water as 1,0075 to 1,0000.

In the proceſs by lixiviation, the ants are waſhed in cold water; and boiling water is afterwards poured over them, which is filtered when cold. More boiling water is poured over the reſidue, and likewiſe filtered when cold. By this means one pound of ants affords a pint of acid as ſtrong as vinegar, and of a greater ſpecific gravity. Meſſrs. Ardvidſſon and Oerhn are of opinion that this acid might be ſubſtituted inſtead of vinegar for domeſtic uſes.

The acid obtained by theſe proceſſes is never pure; but it may be purified by repeated diſtillations, which diſengage the ponderous and volatile oil, and render the acid as clear as water. This acid, when rectified by this proceſs, was found by Meſſrs. Ardvidſſon and Oerhn to have a ſpecific gravity of 1,0011 to 1.

The acid of ants may likewiſe be obtained by placing linen cloths impregnated with alkali in an ant-hill. From theſe the formiate of potaſh, of ſoda, and ammoniac, may be obtained by lixiviaton. The formic acid has ſome reſemblance to the acetous acid ; but the identity of theſe two acids has not yet been proved. Mr. Thouvenel found more analogy between it and the phoſphoric acid: but all this wants proof.

The formic acid retains water with ſo much force, that it cannot be entirely deprived of it by diſtillation. When it is exceedingly pure, its ſpecific gravity is to that of water as 1,0453 to 1.

It affects the noſe and the eyes in a peculiar manner, which is not diſagreeable. Its taſte is penetrating and burning when pure, but agreeable when diluted with water.

It poſſeſſes all the characters of acids.

When boiled with the ſulphuric acid, it turns black as ſoon as the mixture is heated. White penetrating vapours ariſe ; and when it boils a gas is emitted, which unites difficultly with diſtilled water. or with lime-water. The formic acid is decompoſed in this operation, for it is obtained in leſs quantity.

The nitric acid diſtilled from it deſtroys it completely ; a gas ariſes which renders lime-water turbid, and is difficultly and ſparingly ſoluble in water.

The muriatic acid only mixes with it, but the oxigenated muriatic acid decompoſes it.

Meſſrs. Ardvidſſon and Oerhn have determined the affinities of this acid with various baſes in the following order: barytes, potaſh, ſoda, lime, magneſia, ammoniac, zinc, mangaeſe, iron, lead, tin, cobalt, copper, nickel, biſmuth, ſilver, alumine, eſſential oils, water.

This acid mixes perfectly with ſpirit of wine. It unites difficultly with the fixed oils, and with the volatile oils, by the aſſiſtance of heat. It attacks ſoot; aſſumes a fawn colour; and lets fall a brown ſediment as it cools, which by diſtillation affords a liquor of a yellowiſh colour, and a diſagreeable ſmell, accompanied with elaſtic vapours.

CHAP. XI.

Concerning Putrefaction.

EVERY living body, when once deprived of life, performs a retrograde proceſs, and becomes decompoſed. This decompoſition is called Fermentation in vegetables, and Putrefaction in animal ſubſtances. The ſame cauſes, the ſame agents, and the ſame circumſtances, determine and favour the decompoſition of vegetables and animals, and the difference of the productions which are obtained, ariſes from the difference of the conſtituent parts of each.

Air is the principal agent of animal decompoſition, but water and heat prodigiouſly facilitate its action. "Fermentatio ergo definitur quod ſit corporis denſioris rarefactio, particularumque aërearum interpoſitio: ex quo concluditur debere in aëre fieri nec nimium frigido, ne rarefactio impediatur; nec nimium calido, ne partes raribiles expellantur."—Becher, Phyſ. Sub. lib. i. ſ. 5. p. 313. edit. Francofurti.

An animal ſubſtance may be preſerved from putrefaction by depriving it of the contact of air; and this proceſs may be accelerated or retarded by varying or modifying the purity of the ſame fluid.

In thoſe circumſtances wherein we ſee putrefaction developed without the contact of atmoſpherical air, the effect is produced by the water which impregnates the animal ſubſtance, becomes decompoſed, and affords the element and the agent of putrefaction. Hence no doubt it ariſes that putrefaction is obſerved in fleſh cloſed in a vacuum.—See Lyons, Tentamen de Putrefactione.

Moiſture is likewiſe an indiſpenſable requiſite to facilitate putrefaction; and any ſubſtance may be defended from this change by completely drying it. This was performed by Villaris and Cazalet of Bourdeaux, by means of ſtoves. The meat thus prepared was preſerved for ſeveral years without having contracted any bad flavour. The ſands and light porous earths preſerve the bodies of men only by virtue of the property of exhauſting their juices, and drying the ſolids. From this cauſe it is that entire caravans have been diſcovered in Arabia, conſiſting of men and camels perfectly preſerved in the ſands under which the impetuous winds have buried them. In the library of Trinity College of Cambridge, in England, a human body may be ſeen perfectly preſerved, which was found under the ſand in the iſland of Teneriffe. Too much humidity impedes putrefaction, according to the obſervation of the celebrated Becher: "Nimia quoque humiditas a putrefactione impedit, prout nimius calor; nam corpora in aqua potius gradatim conſumi quam putreſcere, ſi nova ſemper affluens ſit, experientia docet: unde longo tempore integra interdum ſubmerſa prorſus a putrefactione immunia vidimus; adeo ut nobis aliquando ſpeculatio occurreret, tractando tali modo cadavera anatomiæ ſubjicienda, quo diutius a fœtore et putrefactione immunia forent." Phyſ. Sub. lib. i. ſ. 5. cap. 1. p. 277.

In order therefore that a body may putrefy, it is neceſſary that it ſhould be impregnated with water, but not that it ſhould be inundated. It is likewiſe neceſſary that this water ſhould remain in the texture of the animal body without being renewed. This condition is requiſite—1. To diſſolve the lymph, and to preſent to the air the moſt putreſcible ſubſtance with the greateſt extent of ſurface. 2. In order that the water may itſelf become decompoſed, and by this means afford the putrefactive principle. Putrefaction is retarded and ſuſpended by baking, becauſe the fleſh is dried, and by that means deprived of the humidity, which is one of the moſt active principles of its decompoſition.

A moderate degree of heat is likewiſe a condition favourable to the animal decompoſition. By this heat the affinity of aggregation between the parts is weakened, and conſequently they aſſume a ſtronger tendency to new combinations. Hence it ariſes that fleſh meat keeps longer during the winter than in ſummer, and better in cold than in hot countries. Becher has given a very intelligent ſketch of the influence of temperature on animal putrefaction. "Aër calidus et humidus maximè ad putrefactionem facit . . . . corpora frigida et ſicca difficultèr, imo aliqua prorſus non putreſcunt, quæ ab imperitis proinde pro ſanctis habita fuere; ita aër frigidus et ſiccus, imprimis calidus et ſiccus, a putrefactione quoque preſervat; quod in Hiſpania videmus, et locis aliis calidis, ſicco-calido aëre præditis, ubi corpora non putreſcunt et reſolvantur; nam cadavera in oriente in arena, imo apud nos arte in furnis, ſiccari, et ſic ad finem mundi uſque à putredine præſervari, certum eſt: intenſum quoque frigus a putredine præſervare; unde corpora Stockholmiæ tota hyeme in patibulo ſuſpenſa ſine putredine animadvertimus." Phyſ. Sub. l. i. cap. i.

Such are the cauſes which are capable of determining and favouring putrefaction; and hence we may perceive the beſt means of preventing, increaſing, or modifying it at pleaſure. A body will be preſerved from putrefaction by depriving it of the contact of atmoſpherical air: for this purpoſe nothing more is required than to place the body in a vacuum, or to envelop it in a covering which may defend it from the immediate action of the air; or elſe to envelop it in an atmoſphere of ſome gaſeous ſubſtance which does not contain vital air. We ſhall obſerve, on this ſubject, that the effects obſerved in fleſh expoſed in the carbonic acid, nitrogene gas, &c. are referable to a ſimilar cauſe; and it appears to me that it is without ſufficient proof that a concluſion has been drawn, that theſe ſame gaſes, internally taken, ought to be conſidered as antiſeptic; becauſe, in the caſes we have mentioned, they act only by defending the bodies they ſurround from the contact of vital air, which is the principle of putrefaction. Putrefaction may be favoured by keeping bodies at a ſuitable temperature. A degree of heat from fifteen to twenty-five degrees diminiſhes the adheſion of the parts, and favours the action of the air: but if the heat be greater it volatilizes the aqueous principle, dries the ſolids, and retards the putrefaction. It is neceſſary, therefore, for the decompoſition of an animal—1. That it have the contact of atmoſpheric air; and the purer the air is, the more ſpeedy will be the putrefaction. 2. That it be expoſed to a moderate degree of heat. 3. That its texture be impregnated with humidity.—The experiments of Pringle, Macbride, Gardane, have likewiſe ſhewn us, that putrefaction may be haſtened by ſprinkling the animal ſubſtances with water containing a ſmall quantity of ſalt; and it is to a like cauſe that we ought to refer ſeveral proceſſes uſed in kitchens to produce this effect in food, as well as in the preparation of cheeſe, the curing of tobacco, the making of bread, &c.

Becher expreſſes himſelf as follows on the cauſes which produce putrefaction in living bodies:—“ Cauſa putrefactionis primaria defectus ſpiritus vitalis balſamini eſt; ſecundaria, deinde, aër externus ambicus, qui interdum adeo putrefaciens et humidus-calidus eſt, ut ſuperſtitem in vivis etiam corporibus balſaminum ſpiritum vincat, niſi confortando augeatur; ex quo colligi poteſt, præſervantia a putredine ſubtilia ignea oleoſa eſſe debere.”—This celebrated chemiſt concludes, from the ſame principles, that ligatures, copious bleedings, or any debilitation whatever, determines putrefaction. He likewiſe thinks that aſtringents oppoſe putrefaction only by condenſing the texture of the animal parts; for he conſiders rarefaction or relaxation as the firſt effect of putrefaction. He thinks that ſpirituous liquors act as antiputreſcent merely by animating and ſtimulating the vis vitæ. He affirms that the uſe of ſalted meats, which heat much, aſſiſted by the moiſture very common in ſhips and ſea-ports, produces the ſcurvy; and he obſerves, with reaſon, that the tendency and effect of putrefaction are diametrically oppoſite to thoſe of generation: "nam ſicut in generatione partes coagulantur et in corpus formantur, ita in putrefactione partes reſolvuntur et quaſi informes fiunt."

As the phenomena of putrefaction vary according to the nature of the ſubſtances themſelves, and the circumſtances which accompany this operation, it follows that it muſt be very difficult to deſcribe all the phenomena which it exhibits. We ſhall therefore endeavour to trace only thoſe which appear to be the moſt conſtant.

Every animal ſubſtance expoſed to the air at a temperature above ten degrees of Reaumur, and moiſtened with its own ſerous humour, putrefies;

trefies; and the progreſs of this alteration appears in the following order.

The colour firſt becomes pale; its conſiſtence diminiſhes; its texture becomes relaxed; the peculiar ſmell of freſh meat diſappears, and is ſucceeded by a faint and diſagreeable ſmell. The colour itſelf at this time inclines to blue; as we ſee in game which begins to turn, in wounds which fall into ſuppuration, in the various parts threatened with gangrene, and even in that putrefaction of the curd which forms cheeſe. Moſt of our food ſuffers the firſt degree of putrefaction before we uſe it.

After this period the animal parts become more and more ſoftened, the ſmell becomes fetid, and the colour of an obſcure brown; the fibrous part eaſily breaks; the texture becomes dry, if the putrefaction be carried on in the open air; but the ſurface becomes covered with ſmall drops of fluid, if the decompoſition be made in veſſels which oppoſe its evaporation.

To this period ſucceeds that which moſt minutely characterizes animal putrefaction. The putrid and nauſeous ſmell which was manifeſted in the ſecond degree, becomes mixed with a ſmell of a more penetrating kind, ariſing from the diſengagement of ammoniacal gas: the maſs becomes ſtill leſs and leſs conſiſtent.

The laſt degree of decompoſition has its peculiar characters. The ſmell becomes faint, nauſeous, and exceedingly active. This, more eſpecially, is contagious, and tranſmits the ſeeds of infection to a great diſtance: it is a true ferment, which depoſits itſelf upon certain bodies, to appear again at long intervals. Van Swieten reports, that the plague having appeared at Vienna in 1677, and having again appeared in 1713, the houſes which had been infected at its firſt appearance were likewiſe infected at the ſecond. Van Helmont aſſerts that a woman contracted an anthrax at the extremity of her fingers, in conſequence of having touched papers impregnated with peſtilential virus. Alexander Benedictus has written that pillows re-produced the contagion ſeven years after having been infected; that cords had remained infected for thirty years, and likewiſe communicated it, according to Foreſtus. The plague at Meſſina was for a long time concentrated in the warehouſes where merchandize was incloſed with the ſuſpected bales. Mead has tranſmitted the moſt alarming facts concerning the durable impreſſion of contagion.

When the putrefying ſubſtance is in its laſt ſtage, the fibrous texture is ſcarcely diſcernible, and has no longer any appearance but that of a ſoft, diſorganized, and putrid maſs. Bubbles are ſeen to eſcape from the ſurface of this matter; and the whole ends by its drying, and becoming reduced to an earthy matter, which is friable when taken between the fingers.

We do not ſpeak of the production of worms; becauſe it appears to be proved that they owe their origin only to the flies which endeavour to depoſit their eggs upon ſuch bodies as are beſt ſuited to ſupport the young they contain. If fleſh meat be well waſhed, and left to putrefy under a ſieve, it will paſs through all the degrees of putrefaction without the appearance of worms. It has been obſerved that worms are of a different ſpecies, according to the nature of the diſeaſe, and the kind of animal which putrefies. The exhalation which ariſes from bodies, in theſe different caſes, attracts different ſpecies of inſects according to its nature. The opinion of thoſe who believe in ſpontaneous generation, appears to me to be contrary to the experience and wiſdom of nature, which cannot have committed the re-production and number of the ſpecies to chance. The progreſs of nature is the ſame for all the claſſes of individuals; and ſince it is proved that all the known ſpecies are re-produced in one and the ſame manner, how can we ſuppoſe that nature departs from her plain and general laws for the ſmall number of individuals whoſe generation is leſs known to us?

Becher had the courage to make obſervations, during the courſe of a year, upon the decompoſition of a carcaſe in the open air; and to obſerve all the phenomena. The firſt vapour which riſes, ſays he, is ſubtile and nauſeous: ſome days after, it has a certain ſour and penetrating ſmell. After the firſt weeks, the ſkin becomes covered with a down, and appears yellowiſh; greeniſh ſpots are formed in various places, which afterwards become livid and black; a thick moſſy or mouldy ſubſtance then covers the greateſt part of the body; the ſpots open, and emit a ſanies.

Carcaſes buried in the earth preſent very different phenomena; the decompoſition in a burying-ground is at leaſt four times as ſlow. It is not perfectly ended, according to Mr. Petit, till three years after the body has been interred, at the depth of four feet; and it is ſlower in proportion as the body is buried at a greater depth. Theſe facts agree with the principles which we have already eſtabliſhed for bodies buried in the earth, and ſubjected to laws of decompoſition very different from thoſe which take place in bodies expoſed to the open air. In this caſe the decompoſition is favoured by the waters which filter through the earth, and diſſolve and carry with them the animal juices. It is alſo favoured by the earth, which abſorbs the juices with more or leſs facility. Meſſrs. Lemery, Geoffroy, and Hunaud have proved that argillaceous earths exert a very ſlow action upon bodies; but when the earths are porous and light, the bodies then dry very ſpeedily. The ſeveral principles of bodies abſorbed by the earth, or carried by the vapours, are diſperſed through a great ſpace, imbibed by the roots of vegetables, and gradually decompoſed. This is what paſſes in burying-grounds in the open air; but it is very far from being applicable to the ſepulchres which are made in churches and covered places. Here is neither water nor vegetation; and conſequently no cauſe which can carry away, diſſolve, or change the nature of the animal fluids: and I cannot but applaud the wiſdom of government, which has prohibited the burying in churches; a practice which was once a ſubject of horror and infection.

The accidents which have happened at the opening of graves and vaults are but too numerous, to render any apology neceſſary for our ſpeaking a few words reſpecting the method of preventing them.

The decompoſition of a body in the bowels of the earth can never be dangerous, provided it be buried at a ſufficient depth, and that the grave be not opened before its entire and complete decompoſition. The depth of the grave ought to be ſuch that the external air cannot penetrate it; that the juices with which the earth is impregnated may be conveyed to its ſurface; and that the exhalations, vapours, or gaſes, which are developed or formed by decompoſition, ſhould not be capable of forcing the earthy covering which detains them. The nature of the earth in which the grave is dug, influences all its effects. If the ſtratum which covers the body be argillaceous, the depth of the grave may be leſs, as this earth difficultly affords a paſſage to gas and vapour; but in general it is admitted to be neceſſary that bodies ſhould be buried at the depth of five feet, to prevent all theſe unhappy accidents. It is likewiſe neceſſary to attend to the circumſtance, that a grave ought not to be opened before the complete decompoſition of the body. This decompoſition, according to Mr. Petit, is not perfect until the expiration of three years, in graves of four feet depth; or four years when they are ſix feet deep. This term affords many varieties, according to the nature of the earth, and the conſtitution of the ſubjects buried in it; but we may conſider it as a medium. The pernicious cuſtom which allows a ſingle grave to families more or leſs numerous ought therefore to be ſuppreſſed; for in this caſe the ſame grave may be opened before the time preſcribed. Theſe are abuſes which ought to occupy the attention of government; and it is time that the vanity of individuals ſhould be ſacrificed to the public ſafety. It is likewiſe neceſſary to prohibit burying in vaults, and even in coffins. In the firſt caſe, the principles of the bodies are ſpread into the air, and infect it; in the ſecond, their decompoſition is ſlower and leſs perfect.

If theſe precautions be neglected; if the dead bodies be heaped together in too confined a ſpace; if the earth be not proper to abſorb the juices, and decompoſe them; if the grave be opened before the entire decompoſition of the body—unhappy accidents will, no doubt, be produced; and theſe accidents are but too common in great towns where every wiſe precaution is neglected. An inſtance of this happened when the ground of the church of St. Benoit at Paris was dug up a few years ago:

a nauſeous vapour was emitted, and ſeveral of the neighbours were affected by it. The earth which was taken out of this grave was unctuous, viſcid, and emitted an infectious ſmell. Meſſrs. Maret and Navier have left us ſeveral ſimilar obſervations.

INDEX.

INDEX.

N. B. The Roman Letters denote the Volume, and the Arabic Figures the Page. Where there is no Roman Letter the firſt Volume is to be underſtood.

A

ACIDS, 184
Acid, acetous, III. 270
Acid of Amber, III. 219
—— Animal, III. 388
—— of Benzoin, III. 79
—— of Borax, 263
—— of Camphor, III. 67
—— Carbonic, 195
—— Citric, III. 128
—— of Fat, III. 311
—— Fluoric, 43
—— Lactic, III. 293
—— Malic, III. 130
—— of Molybdena, II. 486
—— Muriatic, 237
———— Oxigenated,
—— Nitric, 217
—— Nitro-muriatic, 260
—— Oxalic, III. 113
—— of Phoſphorus, III. 356
—— Pruſſian, II. 374
—— Pyro-ligneous, III. 127
—— Pyro-mucilaginous, III. 225
—— of Sugar of Milk, III. 296
—— Sulphuric, 205
—— of Tartar, III. 267
—— of Tungſten, II. 470
Affinity, 22, et ſeq.
Agate, II. 126
Aggregation, 23
Air atmoſpheric, 141
Air vital, 113
Alabaſter, II. 23
Alchemiſts, II. 455
Alcohol, III. 257
Alkalis, 170—187; III. 137
Alkaline Gas, 180
Aloes, III. 86
Alum, II. 62
Alumine, II. 13
Aluminous Salts, II. 6
Amalgam, II. 324
Amber, III. 217
Amianthus, II. 84
Ammoniac, 178. Sal, 256
Animal Subſtances, III. 279
Antimony, II. 249
Apparatus Pneumatic, 100
Aqua regia, 262
Arbor Dianæ, II. 434
Archil, III. 153
Aroma, III. 189
Arſenic, II. 120
Aſbeſtos, II. 82
Aſphaltes, III. 116
Aſa Fœtida, III. 85
Attraction, 22, et ſeq.
Aurum Muſivum, II. 324
Azure, II. 236

B

Balances, 21
Balloon Air, 109
Balſams, III. 70—77
Bark of Vegetables, III. 12
Barytes, II. 10
Baſaltes, II. 138
Benzoin, III. 77
Beryl, II. 111
Bile, III. 315
Biſmuth, II. 243
Bleaching, 253
Blende, II. 272

Blood, 132; III. 302
Borate of Ammoniac, 273
—— of Potaſh, 267
—— of Soda, 268
Borax and its Acid, 263, et ſeq.
Brandy, III. 251
Brewing, III. 248
Bronze, II. 401
Butter, III. 301

C

Cacholong, II. 129
Calcedony, II. 128
Caloric, 64
Camphor, II. 64
Cantharides, III. 381
Caoutchouc, III. 87
Carbone, 95
Carbonate of Ammoniac, 203
———— of Potaſh, 201
———— of Soda, 202
———— of Lime, II. 16
Carnelian, II. 130
Caſſava, III. 98
Caſtoreum, III. 371
Cat's Eye, II. 128
Charcoal, 95; III. 398
Cheeſe, III. 299
Chemiſtry, 1
Chryſolite, II. 111
Chryſopraſe, II. 144
Cinnabar, II. 422
Clay, 14
Cobalt, II. 233
Copper, II. 383
Cream, III. 301
Crucibles, 13
Cryſtal, II. 116
Cryſtallization, 33, et ſeq.

D

Diamond, II. 170
Digeſtion, III. 285
Diſtilling, 11
Dyeing, Arts of, III. 140

E

Eagle Stone, II. 340
Earth, II. 1
Earth, Calcareous, II. 9
—— Ponderous, II. 10
—— Magneſian, II. 12
—— Aluminous, II. 13
—— Siliceous, II. 15.
Egg, III. 300. 379
Elaſtic Gum, III. 87
Elements, 60
Emerald, II. 111
Ether, III. 258
Ethiops Martial, II. 362
Evaporation, 7.

F

Fat, III. 309
Fayence, II. 90
Fecula, III. 56
Feld Spar, II. 146
Fermentation, III. 239. 268. 173
Fire, 62, et ſeq.
Fleſh, III. 322
Flints, II. 124
Fluate of Lime, II. 42
Fluor Spar, II. 42
Fulminating Silver, II. 436
———— Gold, II. 450
Furnaces, 3, et ſeq.
Fuſible Spar, II. 42

G

Galena, II. 294
Garnets, II. 108
Gaſes, 97
Gaſtric Juice, III. 287
Geology, II. 177
Giraſol, II. 128
Glaſs, II. 139
Gluten, Vegetable, III. 103
Glue, III. 326
Gold, II. 439
Gums, III. 38
Gum Guttæ, III. 85
Gunpowder, 234
Gypſum, II. 36

H

Heat, 64, et ſeq.
Hematites, II. 74
Hepatic Stone, II. 75
Honey, III. 165
Horn Stone, II. 97
Hyacinth, II. 109
Hydrogenous Gas, 102
Hydrophanes, II. 130

I

Jaſper, II. 131
Jelly, III. 323
Jet, III. 233
Indigo, III. 147

Iron, II. 326
Iſinglaſs, III. 327

K

Kaolin, 94
Kermes, III. 386

L

Labdanum, III. 75
Laboratory, 2
Lac, III. 387
Lapis Lazuli, II. 144
Lapis Infernalis, II. 433
Lava, II. 137
Lead, II. 293
Light, 83; III. 33
Lime, II. 9. 30
Liquorice, III. 205
Lithology, II. 1. et ſeq.
Luna Cornea, II. 435
Lutes, 15.

M

Magneſia, II. 12
Magneſian Salts, II. 55
Magnet, II. 332
Manganeſe, II. 280
Manna, III. 177
Marble, II. 22
Maſtic, III. 74
Mecca, Balſam of, III. 70
Mercury, II. 404
Murcurius Dulcis, II. 421
Metals, II. 197
Mica, II. 95
Milk, III. 289
Mines, II. 201
Molybdena, II. 481
Mongolfier, 109
Mortar, II. 33
Mountain Cork, II. 82, 83
Mucilage, III. 36
Muriate of Ammoniac, 256
——— of Potaſh, 249
——— of Soda, 250
——— of Lime, II. 48
Muſk, III. 373

N

Naptha, III. 114
Nickel, II. 240
Nitrate of Ammoniac, 336
——— of Potaſh, 219
——— of Soda, 230
Nitrate of Lime, II. 147
Nitrogene Gas, 138
Nitro-muriatic Acid, 260
Nitrous Gas, 223

O

Oculus Mundi, II. 130
Oils, III. 41
Olibanum, III. 83
Opal, II. 127
Opium, III. 177
Orpiment, II. 225
Oxigenous Gas, 113; III. 185
Oxides, 193

P

Perfumes, III. 193
Petroleum, III. 214
Petroſilex, II. 125
Pewter, II. 320
Phoſphate of Lime, II. 49; variors, III. 341
Phoſphoric Gas, III.
Phoſphorus, III. 350
Pit-Coal, III. 209
Pitch, III. 73
Plaſter Stone, II. 36
Platina, II. 458
Plumbago, II. 342
Pollen, III. 160
Ponderous Earth, II. 10
Porcelain, II. 92
Porphyry, II. 163
Pottery, II. 88
Pot Stone, II. 79
Powder, Fulminating, 235
Precipitate, 30
Pruſſian Blue, II. 369
Putrefaction, III. 273. 395
Pyrites, 111
Pyrometer of Wedgwood, 68

Q

Quartz, II. 116. 122

R

Realgar, II. 225
Receivers, 12
Reſins, III. 69
Reſpiration, 125
Retorts, 9
Ruby, II. 107

S

Sago, III. 99
Sandarach, III. 75
Sal Ammoniac, 256
Salt, Common, 251
Salt Petre, 250
Sapphire, II. 114
Scammony, III. 83
Schorles, II. 132
Selenite, II. 36
Serpentine, II. 80
Serum, III. 305
Siderite, II. 360
Silex, II. 15
Silver, II. 425
Size, III. 328
Slate, II. 99
Smalt, II. 237
Soap, III. 53
Soap Stone, II. 79
Soil, III. 28
Solution, 42
Soup, III. 324
Spar, Ponderous, II. 51
Spermaceti, III. 377
Starch, III. 101
Steatites, II. 79
Steel, II. 357
Stone, II. 1; of the Bladder, III. 345
Sublimate Corroſive, II. 417
Sublimation, 9
Sugar, III. 108
Sulphate of Ammoniac, 215
——— of Potaſh, 212
——— of Soda, 213
——— of Lime, II. 36
Sulphur, 88. 205
Swine Stone, II. 73

T

Talc, II. 77
Tartar, III. 264
Tin, II. 311
Tinning of Copper, II. 401
Topaz, II. 109
Tourmalin, II. 134
Trapp, II. 143
Trompe, II. 213
Tungſten, II. 468
Turnſole, 189

U

Ultramarine, II. 145
Urine, III. 334

V

Varniſh, III. 91
Vegetables, III. 1
Vermilion, II. 422
Veſſels, Chemical, 4, et ſeq.
Vinegar, III. 269
Violets, Syrup of, 185
Vital Air, 113
Volcanic Products, II. 137
Volcanos, III. 221

W

Water, its Compoſition, 145. 159; III. 22
Waters, Mineral, 274
Wax, III. 163. 166
Wolfram, II. 475
Wood, III. 15
Woulfe, his Apparatus, 17

Z.

Zaffre, II. 236
Zeolite, II. 104
Zinc, II. 270.

FINIS.

R. Noble, Printer,
Old Bailey.